J. Poole Sculpt

THE
NAVIGATOR's
VENI-MECUM,
OR
A Complete Syſtem of the
ART OF NAVIGATION;

CONTAINING

Every thing neceſſary to be known in Arithmetic, Geometry, and Trigonometry, to qualify a perſon for keeping an accurate, rational, and true Account of a Ship's way at Sea. And alſo how to direct her to any Port deſired.

To which are added Traverſe tables, tables of Logarithms, Sines, Tangents, &c. which render this work complete and independent.

How wonderful is the way of a Ship in the midſt of the Sea?
PRO. XXX, 18.

By J. DRAPER Teacher of the Mathematicks, and Author of the Young Student's Pocket Companion.

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PREFACE.

NAVIGATION, in its preſent ſtate of Perfection, has, without doubt, been the reſult of many ages; and the Sacred Hiſtory is not wholly ſilent of its antiquity; For the patriarch Jacob, when in Egypt, bleſſed his ſons, made mention of Havens and Ships. Again we find the Tyreans and Phœnecians were early concerned in a coaſting Navigation: Alſo king Solomon made a Navy of Ships, and Hiram, king of Tyre, ſent mariners, or ſhip-men, his ſervants, that had knowledge of the ſea, to aſſiſt and inſtruct the ſervants of king Solomon, in the piloting and navigating of the navy which he had ordered to be made: But to whom the world is indebted for the invention of Ships, is like other things of equal antiquity, very uncertain.

REMOTE NAVIGATION has had its riſe and progreſs in the latter ages, after the invention of the Compaſs; for Pliny writes of carrying birds to ſea, in his time, in caſe the ſhip ſhould happen to be drove out of ſight of land, which they let go, ſuppoſing that by inſtinct, peculiar to their nature, they would fly towards the ſhore.

THE Phœnicians made a voyage on the Mediteranean, from Zidon to Greece, carried away Io, the daughter of Inachus, who came with other Grecian women to their ſhip's to buy merchandize before Chriſt 1047.

SOLOMON's fleet on the Red ſea was 1017 years before Chriſt. The Greek's ordered the building of the ſhip Argo, (after the pattern of the long ſhip, in which Danaus came into Greece,) for the Euxine and Mediterranean ſeas, about 940 years before our Saviour, and the beſt Chronologer's make the Argonantic expedition about 3 years later.

The Phœnicians ſailed as far as the Straits of Gibralter or beyond, * A. C. 883. And the Corinthians built ſhips with three orders of oars, called Triremes. The Greeks, having heretofore, uſed long veſſels of 50 oars A. C. 697. Alſo, the oldeſt Sea-fight is ſaid to be 657. A. C. Hiſtory makes mention of Ptolomy Philopater, being urged by a vain ambition to exceed all the world beſide, built a veſſel, of ſuch enormous bulk, that ſhe appeared at diſtance like a floating mountain or iſland, which contained Four Thouſand Rowers, Four Hundred Sailors otherwiſe employed, and near Three Thouſand Soldiers. But this, and all ſuch monſtrous fabrics, ſerved only for ſhew and oſtentation, their vaſt bulk rendering them unfit for ſervice.

NAVIGATION is an art ſo extenſively uſeful, that, of all others, it claims our utmoſt regard in order to promote and encourage it, as it is principally owing thereto that Britain is enabled to partake of the produce of both Indies; and mentains a kind of ſovereignity over the main.

NAVIGATION finds employment Directly, or Indirectly, for many thouſands; Directly, employed in building and navigating merchants ſhips and ſhips of war; Indirectly, as it is by means thereof, that the merchant is enabled to tranſport, the overplus produce, of all kinds of our manufactories, to the moſt remote and diſtant regions of the globe, and; and bring us home, in exchange the valuable productions of thoſe diſtant countries.

NAVIGATION, with reſpect to THEORY, is ſupported by the three ſtrong pillars, viz. ARITHMETIC, GEOMETRY, and TRIGONOMETRY. Therefore, every Navigator ſhould underſtand Numbers, Lines, and the Affections of Triangles.

IN this courſe, called the NAVIGATOR'S VENI-MECUM, we have, by way of introduction, pointed out the riſe and progreſs of the antient Navigation; and alſo pointed out the capital theories and anologies made uſe of by the Moderns; ſo that in little more than 30 pages of this ſmall volume, you have a complete view of the whole myſtery of Modern Navigation, in the follow-

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* A. C. ſtands for Ante Chriſtum, that is, before Chriſt.

ing modes of ſailing; as Plain, Traverſe, Parallel, Mercators, and Middle Latitude Sailing, the Theory of Latitude, Longitude, Sun's Declination, Variation of the Compaſs, Leeway, of Obſervations, Keeping a Sea Reckoning, with the Neceſſary Corrections. To find the new and full Moons, her Age and Southing, To reckon the Tides, &c. To which is added, the Geographical diviſion of the Earth into Anteoci Perieci and Antipodes, A ſhort view of the Copernican Syſtem of the Univerſe, and a few ſurpriſing Paradoxes with their Solutions.

In the body of the work is given an explanation of the ſigns, marks, or characters, adopted by mathematicians, the firſt fundamental rules in ARITHMETIC relative to pure numbers, Compound Multiplication, Diviſion, Reduction, Rule of Proportion, the doctrine of Decimal Arithmetic, with it's application to the meaſurement of Bales, Caſes, or Packages; the Square root and its uſe, performed by Logarithms; the uſe of Gunter's Scale with compaſſes, and Sliding Gunter in board and timber meaſure, proved by the pen; with Caſk Guaging and the Meaſurement of Ships, &c. The conſtruction of the plain Scale, and of the Lines put on Gunter's Scale, as Numbers, Sines, Tangents, Verſed Sines, Sines and Tangents of Rhumbs. Problems in Geometry, a Synopſis of the ſix Caſes of Right angled Triangles, with examples in Caſes 1ſt. and 4th. worked out Geometrically, by Logarithms, by Natural Sines: alſo Inſtrumentally, by Gunter's Scale with Compaſſes, by the ſliding Gunter, by the Sector, and by a method purely Arithmetical, independent of tables. Then follows Plain Sailing, in all its parts as Meridional, Equatorial, and Loxodromic, illuſtrated with pertinent examples, worked out at large in all caſes, with rules and examples reſpecting Latitude, Traverſe Sailing, Geometrically, Inſtrumentally by Gunter with Compaſſes, ſliding Gunter, by the Traverſe Table, and by the Table of Natural ſine, Arithmetically; Parrallel Sailing, with rules and examples reſpecting Longitude, in five different caſes.

MERCATOR'S SAILING, by a table of Meridional Parts, Geometrically, Inſtrumentally, by Middle Lattitude, by Logarithms, by Natural ſines, by Logarithm tangents, in all the various caſes thereof. The THEORY of the Sun's Declination, rules and examples, for working Obſervations made at Sea, in all caſes with great accuracy; allowing for the Sun's Semidiameter, Refraction, Height of the Eye of the Obſerver, with the correction of Tabular declinations to remote Longitudes. The Variation of the Compaſs, Geometrically, by an Amplitude, by an Azimuth compaſs at Mid-day, by Two equal Altitudes of the Sun and their correſponding Azimuths. To work a Day's Reckoning, to keep a Journal of a Ship's Way at Sea, illuſtrated by Six Days ſailing, from Cape Clear in Ireland, towards Cape Henry in Virginia. The uſe of the Plain and Mercator's Chart in ſailing, with the method of pricking the Ship on the Chart, &c. To which is added, the following uſeful and neceſſary tables, viz. A table of the Declinations of a few of the moſt eminent fixed ſtars, adjuſted to the begining of the year 1774, A table of the Obſerved Variation of the compaſs, in many places of the world, A Tide table ſhewing High water, at a number of places frequented by Navigators, on the Full and Change Days, to be added to the time of Moon's Southing at other ages, for the time of High-water then and there. An extenſive Sea-coaſt table of the Latitudes, and Longitudes, of many of the principal Harbours, Capes, Iſlands, Bays, &c. in the known world, A table of the Sun's Declination and explanation of a particular artifice to render it perpetual, A table whereby the Sun's Amplitude may be found as far as 60 Degrees, North or South at any time, by means of the Declination; for the more ready finding the Variation of the compaſs. An extenſive Traverſe table, with its explanation, to anſwer all the purpoſes of the *Seaman's Daily Aſſiſtant*, in all the Caſes of Sailing, with reſpect to Courſe, Diſtance, Difference of Latitude, Departure, Difference of Longitude, &c. A table of Logarithms, ſufficient to anſwer all the purpoſes of a Navigator, for ſuch as chooſe to work thereby. A table of Logarithms, Sines, and Tangents to every 5th Minute of the Quadrant, and the explanation of a peculiar artifice to make them anſwer to every Minute of the Quadrant. A table of Natural Sines and Tangents, on the ſame plan for every 15th. min.

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INTRODUCTION.

NAVIGATION is twofold, *viz.* HOME and REMOTE; the ancients knew only the former, the moderns claim the invention of the latter. It conſiſts in the theory and art of conducting a ſhip by ſea, from one port to another, or of diſpoſing and actuating her machinery by the force of the wind, ſo as to begin and continue her motion at ſea. This uſeful art and admirable invention, which is the fundamental conſtituent of commerce; the very ſupport of mankind, and ſupplies them with all the neceſſaries and conveniences of life, has at firſt been the production of ſome lucky chance: or from ſlight and contemptible beginnings, has by long experience, cautious obſervations, and various improvements, been matured, and brought to perfection. Inſtances of this kind are frequent and obvious, but none can be produced more remarkable than in the art of Navigation, which altho now arrived to a pitch of perfection beyond moſt other arts, by theſe ſucceſsful additions it has received from almoſt every age of the world, was in the beginning ſo mean and imperfect, that the pleaſure or advantage of thoſe who firſt applied themſelves to it, was both ſmall and inconſiderable.

Thoſe who ventured to commit themſelves to the liquid element, made their firſt eſſays in ſhallow waters, cautious of truſting themſelves at any conſiderable diſtance from the ſhore; but being emboldened by repeated trials, proceeded farther by degrees, till at length they took courage and launched forth into the main ocean. In this early navigation, the maſter or pilot had the care of the ſhip, and government of the ſeamen therein, and ſat at the ſtern to ſteer. All things were managed according to his direction; it was therefore neceſſary that he ſhould have obtained a perfect

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knowledge of the art of NAVIGATION, which conſiſted chiefly in theſe things.

Firſt. In the right management of the rudder, ſails, oars, and all the engines uſed in NAVIGATION.

Secondly. In the knowledge of the winds and celeſtial bodies, their motions and influences.

Thirdly. In the knowledge of commodious harbours, of rocks, quickſands, and other occurrences of the ſea. How much this employment is ſimilar to the duty of the officer who manages the navigation in our ſhips of war, would be needleſs to mention.

As to the heavenly bodies, they were obſerved by ſailors on a twofold account, being of uſe to them in prognoſticating the ſeaſons, and as guides to ſhape their courſe. The principal of thoſe uſed in foretelling, were ARCTURUS, SIRIUS, ORION, HYADES, PLEIADES, CASTOR and POLUX, &c. It was likewiſe cuſtomary to take notice of various omens offered by ſeafowls, fiſhes, and divers other things, as the murmuring of the floods, the ſhaking and buzzing noiſe of trees in the neighbouring wood, the daſhing of the billows againſt the ſhore; and many more, in which all good pilots were nicely ſkilled. As to the direction in their voyage, the firſt practitioners in the art of NAVIGATION, being unaquainted with the reſt of the celeſtial motions, ſteered all the day by the courſe of the ſun; at night betaking themſelves to ſome ſafe harbour, or reſting on the ſhore, and not daring to venture to ſea till their guide was riſen to diſcover their way. That this was the conſtant cuſtom may be gathered from VIRGIL's deſcription of thoſe times.

Afterwards the Phœnicians, called by ſome the firſt inventors of NAVIGATION, diſcovered the motions of ſome other ſtars, as may be obſerved by PLINY and PROPERTIUS.

The Phœnicians we find to have been directed by CYNOSURA or the leſſer bear; which was firſt obſerved, as ſome are of opinion, by THALES the Mileſian, who was originally a Phœnician, when the mariners of Greece, as well as other nations, ſteered by URSA MAJOR or the great bear. For the firſt obſervations of this, they were obliged to NAUPLIUS, if we believe THEON; or according to the report of FLACCUS to TIPHYS, the pilot of the famous ſhip ARGO. But of theſe two we are told by THEON, the former was the ſecurer guide, and therefore was followed by the Phœnicians, who, for ſkill in marine affairs, outſtriped not only all the reſt of the world, but even the Grecians alſo.

The commerce, riches, and power of Tyre the capital of Phœnicia, are repreſented, both in ſacred and profane hiſtory, in lofty terms; that country being furniſhed with excellent materials for ſhip building; whence Tyre became miſtreſs of a numerous fleet; and her mercantile inhabitants often embarked on new expeditions, extending their trade and commerce; whereby they ſoon arrived at an extenſive pitch of opulency, and populouſneſs. Hence they were enabled to ſend out colonies, the principal of which was Carthage, which keeping up the Phœnician ſpirit of commerce, not only rivaled that of Tyre, but vaſtly ſurpaſſed it, ſending her fleets through by the pillars of HERCULES, now the ſtraights of Gibralter, along the coaſt of Africa and Europe, if not to America. After ALEXANDER the great ſubdued Tyre, its Navigation and Commerce, were transfered to Alexandria, a city which he had meditated and propoſed for the capital of the Empire of Aſia. Hence ſprung the Navigation of the Egyptians, long cultivated and improved by the PTOLOMIES. After the battle of Actium, Egypt was reduced into a Roman province, and its Trade and Navigation, fell into the hands of AUGUSTUS, Alexandria being then only inferior to Rome. Carthage long diſputed empire with the Romans, at length was ſubdued and ſunk into oblivion, as Tyre had done before. In proceſs of time, Alexandria underwent the fate of Tyre and Carthage, and the fall of Rome and its Empire, drew along with it the polite arts, and that of NAVIGATION: and the Barbarians into whoſe hands it fell, reſted ſatisfied with rioting in the ſpoils of the induſtry and wealth of their predeceſſors. It is preſumed that NAVIGAAION, with other polite arts, travelled eaſtward, altho we are at ſome loſs to aſcertain which of the European Nations, firſt undertook to revive the decayed ſtate of Trade, Navigation, and Commerce, ſome aſcribe it to the French, others to the Italians, but who ever made the firſt advances to reſtore Navigation, at preſent the Britiſh navy hold, an undiſputed empire over the main.

To whom the world is indebted for the invention of ſhips is like all other things of equal antiquity, uncertain; if we liſten to the poets, we ſhall be extremely divided in our opinion, among the variety of competitors, PROMETHEUS, NEPTUNE, JANNUS, ATLAS, HERCULES, JASON, DANAUS, ERYTHRAEUS, &c. appear with ſufficient authority

to

to claim our aſſent; but **Minerva**, the auſpicious parent of Arts and Sciences, ſeems to have a ſuperior title, and to her probably with more properiety, it has been attributed by fame. But ſome totally reject theſe traditions, and aſcribe the invention to the inhabitants of ſome places that border on the ſea, and ſeem appropriated by nature for harbouring ſhips, ſuch as the Phœnicians, Aeginenſieus. However a ſmall portion of art or contrivance, was ſeen in the firſt ſhips, they were neither ſtrong nor durable, but conſiſted only of a few planks laid together, without beauty or ornament, juſt ſo compacted as to keep out the water. In ſome places only the ſtocks or trunks of trees hollowed, and then conſiſted of only one piece of timber, as the American canoe.

Nor was wood alone applied to this uſe, but any bouyant materials, as Egyptian reeds, papyrus, or leather, of which the primitive ſhips were frequently compoſed, the bottoms and ſides being extended on a frame of thin battens or ſcantlings of flexible wood, or begirt with wickers, ſuch as are ſtill in uſe among the American ſavages.

In this manner they were navigated upon the rivers of Ethiopia, Egypt, and Sabean Arabia, even in later times. In a veſſel of this kind **Dardanus** ſecured his retreat to the country afterwards called Troas, when compelled by a terrible deluge, to forſake his habitation of Samothrace.

But as the other arts extended their influence, naval architecture began likewiſe to emerge from the gloom of ignorance and barbariſm, and ſhips in thoſe ages increaſed in bulk, and became better proportioned for Commerce, even down to our own times.

Navigation among the moderns, comprehends either the art of ſeamanſhip, or conducting a ſhip by the laws of **Geometry** upon the wide and tractleſs ocean, or both. By ſeamanſhip is underſtood a perfect knowledge, as well of all the various machinery and furniture of a ſhip, as experience and ſkill to diſpoſe theſe machines ſo judiciouſly, that by a mutual aſſiſtance of each other, they may begin and continue the motion of this complicated frame, according to the different deſigns, which may be required, or the various exigences to which it may be reduced.

It likewiſe includes the art of renewing or keeping in repair the inſtruments and engines, employed in all the purpoſes of Navigation.

Home **Navigation** regards the piloting or guiding a ſhip along the coaſt, and can only be acquired by experience, as it chiefly comprehends a knowledge of the reigning winds, the ſetting of the tides, both in reſpect to direction and time, the different depths of water, and the various ſorts of ground, diſcovered in different depths, as ſhells of many colours, ſand, great and ſmall, clay, ooze, ſhingle, gravel, ſtones, &c. by which the place of the ſhip may be known many times in the darkeſt night, and conſequently her diſtance from ſome known place on the coaſt. The bearings of the neareſt cape, headland, promontory, or iſland, is always ſet by the compaſs, and the diſtance eſtimated; which experience and attention often make the induſtrious ſeaman very perfect in.

The principal articles in coaſting Navigation are, obſerving the motion of the tides, ſounding often, and at all times keeping a good look out.

Remote NAVIGATION, is that by which we underſtand the direction of a ſhip's courſe at ſea, and out of ſight of land, is founded on the principles of TRIGONOTETRY, her progreſs is conſequently meaſured by Geometrical rules, and determined by the ſides and angles of a right angled plain triangle, in which the hypothenuſe is converted into diſtance; the legs into difference of latitude and departure; the acute angles into courſe, and its compliment.

Courſe in NAVIGATION, is the point of the compaſs on which the ſhip ſteers, or it is the angle intercepted between the track of the ſhip and the meridian: which is uſually reckoned in points and quarters, each point 11 deg. 15m. or the 32d. part of the whole circle of 360 degrees.

Departure in NAVIGATION, is the eaſting or weſting of a ſhip, with reſpect to the meridian ſhe ſailed, or departed from.

Diſtance in NAVIGATION, is the number of miles or leagues a ſhip has ſailed, from any point.

Latitude in NAVIGATION and GEOGRAPHY, is the diſtance of any place from the equator, in degrees and minutes upon the meridian of that place, and is either north or ſouth, according as the place is ſituated on the north or ſouth ſide of the equator, and this latitude cannot exceed 90 degrees.

Difference of latitude in NAVIGATION, is the northing or ſouthing of a ſhip, with reſpect to the latitude ſailed from

The courſe of the ſhip is known or determined by the compaſs, and as the mate or perſon at the helm, directs the ſhip's motion by this inſtrument, it is conſequently the firſt thing given in the triangles. The diſtance is the next thing, meaſured by the log-line, and a half or quarter minute glaſs. Log in naval affairs, is a triangular, or ſmall quadrantal piece of board, uſed on board a ſhip, coated with lead along one ſide, or on the quadrantal arch, to make it ſwim upright: this log is faſtened to a line; which line is wound upon a reel. This line is generally divided into certain ſpaces, which are or ought at leaſt to be, ſuch a proportional part of a nautical mile, 60 of which make a degree of a great circle, as half a minute, the time allowed for the experiment, is of an hour. This common nautical or ſea mile, according to an experiment made by Mr. NORWOOD, and with which the French nearly agree is 6120 Engliſh feet, which being divided by 120, the half minutes in an hour gives 51 feet for the diſtance, between each diviſion on the log-line.

Theſe diviſions or ſpaces are called knots, becauſe at the end of each diviſion, there is a peice of twine with knots in it, reeved between the ſtrands of the line, whereby the number of knots, run of the reel, during the half minute, are eaſily counted. And becauſe it is requiſite that the log be out of the eddy of the ſhip's wake, before they begin to count, the knots begin at the diſtance of ten fathoms or ſixty feet from the log, called ſtray-line, at which point for more ready diſcovering of it, there is faſtned a piece of red rag.

Having the log-line thus prepared, and wound upon a reel; the log is hove over board from the poop, and when the red rag is at your hand, let your aſſiſtant turn the half minute glaſs, then veer the line from off the reel, which eaſily turns as the ſhip ſails from the log, till the half minute glaſs is run out, at which time ſtop the line, and the number of knots intercepted between your hand and the red rag, will ſhew how far the ſhip has run in that time, and conſequently her rate of ſailing, as the diſtance between knot and knot, is in the ſame ratio to a nautical mile, as half a minute is to one hour; therefore as many knots as are run out in half a minute, ſo many miles will the ſhip ſail in an hour, ſuppoſing her to move with the ſame velocity during that time.

But as many accidents attend a ſhip during a day's ſailing, ſuch as the variableneſs of the winds, the different quantity of ſail carried, &c. it will be neceſſary to heave the log at every alteration, and though none of theſe alterations be perceptible, yet it ought to be conſtantly heaved, at leaſt once an hour. As the log line may ſhrink or ſtretch, and the half minute glaſs may alter, they ought to be often examined, and when found amiſs, rectified.

The log board is a table generally divided into five columns, in the firſt is entered the hours of the day, in the ſecond the courſe ſteered, in the third the knots run of the reel each time of heaving, in the fourth, from what point the wind blows, and in the fifth obſervations on the weather, variation of the compaſs &c. The log book is ruled into columns, like the log board, into which the account on the log board is tranſcribed, every day at noon, from whence after it is corrected, and worked off by the rules of art &c. it is entered in the Journal.

Thus having the courſe and diſtance given, we diſcover the difference of latitude and departure, by the following anologies; which may be done by GUNTER's ſcale with compaſſes, or ſliding gunter, or by logarithms, or by tables of natural ſines, or by a good traverſe table, as will appear in the conrſe of this work.

As radius
: the diſtance
:: ſine of courſe
: the departure

As radius
: the diſtance
:: ſine comp. of courſe
: diff. of latitude

Thus having found the miles of departure, by which is underſtood the eaſting or weſting, from the firſt meridian, and the miles of northing or ſouthing or the difference of latitude, which operation being performed, at every alteration of the courſe, on a change of wind or other accident, the whole northings, ſouthings, eaſtings, and weſtings, ſailed in twenty four hours are diſpoſed into four columns, and the leſſer numbers of each claſs, ſubtracted from the greater, leave the number of miles north or ſouth called difference of latitude, and of departure eaſt or weſt, then the courſe and diſtance reſulting from theſe traverſes for the twenty four hours is diſcovered, by the following proportions.

As diff. of latitude
: tang. of radius
:: the departure
: tang. of the courſe

And as ſine of courſe
: departure
:: radius
: the diſtance

But if the artiſt in the run of twenty four hours has occaſion to believe from circumſtances, that the angle of the courſe is nearer truth than the ſide called diſtance, and has proved the accuracy of his diff. of latitude by a celeſtial obſervation, he will naturally chooſe to find his diſtance and departure, by the courſe and diff. of latitude, and will then ſay,

As co ſine of courſe
: diff. of latitude
: : radius
: the diſtance

And as radius
: the diſtance
: : ſine of courſe
: departure

On the contrary, if the Navigator has more reaſon to rely on the certainty of the diſtance than of the courſe, and has his diff. of latitude confirmed by a ſolar obſervation, he is then furniſhed with two ſides of a right angled plain triangle, to diſcover the angle of the courſe and third ſide, it will then be.

As diſtance
: radius
: : diff. of latitude
: ſine comp. of courſe
which ſubtracted from 90 deg. gives the angle of the courſe.

Then ſay, as radius
: diſtance
: : ſine of courſe
: departure

But if a ſhip has ſailed between the meridian and parallel, that is any where on an angle between the four cardinal points, and is pretty exact in her courſe, as alſo in the miles of eaſting or weſting ſhe has made, called her departure, although the diſtance ſhe has run is not accurately determined, nor is her difference of latitude aſcertained, then may the two latter *(viz)* the diſtance and diff. of latitude be diſcovered by having the courſe and departure given, thus,

As ſine of courſe
: departure
: : radius
: the diſtance

As tangent of courſe
: departure
: : tangent of radius
: diff. of latitude

Laſtly, If a ſhip has ſailed a known diſtance till the line of her departure is likewiſe aſcertained, and it be required to find the courſe ſhe has ſteered, and the diff. of latitude ſhe has made, then the diſtance and departure being given, the proportions are,

For courſe,
As diſtance
: radius
: : departure
: ſine of courſe

For diff. of latitude,
As tang. of the courſe
: departure
: : tangent of radius
: diff. of latitude

Having the latitude ſailed from, and the diff. of latitude to find the latitude ſhip; obſerve that in north latitude ſailing northward, and in ſouth latitude ſailing ſouthward, the diff. of latitude is an increment, and muſt be added to the latitude ſailed from, to obtain the latitude ſhip.

But in north latitude ſailing to the ſouthward, and in ſouth latitude ſailing to the northward, the diff. of latitude is a decrement and muſt be ſubtracted from the latitude ſailed from, to obtain the latitude ſhip; alſo if you are near the equator in north latitude, and ſail to the ſouthward, or in ſouth latitude and ſail to the northward, until the diff. of latitude exceeds the latitude ſailed from; you ſubtract the latitude ſailed from, from the diff. of latitude, and the reſidue is the latitude of a contrary name to that ſailed from, for the ſhip has croſſed the equinox, and changed her latitude.

As the meridian of the place ſailed from, is always one leg of a right angled triangle in ſailing, and a parallel of latitude the other, it follows, that if a ſhip ſails on one of the cardinal points no triangle is formed by her diſtance, hence if a ſhip ſails due north or ſouth, the diſtance is equal to the diff. of latitude, and if ſhe ſails due eaſt or weſt her diſtance is equal to her departure.

Longitude in NAVIGATION, is the diſtance of a ſhip or place, from ſome firſt meridian, counted in degrees of the equator; or it is an arch of the equator intercepted between the meridian of the place, and firſt meridian.

The diff. of longitude of any two places, is equal to an arch of the equator, intercepted between the two meridians, paſſing through the two places; which is analogous to the quantity of time that the ſun requires to move apparently from the meridian of one place to that of the other, or in the language of thoſe who mentain the PYTHOGREAN ſyſtem, the time that elapſes between the application of the meridian of one of the places to the ſun, and the meridian of the other: for ſince the ſun finiſhes his apparent diurnal revolution in twenty four hours, or, which is the ſame thing, ſince the revolution of the earth about her axis, is performed in the ſame time, it follows that in every hour, there paſſes over the meridian, one twenty fourth part of 360 degrees, or of the whole circumference of the equator, equal to fifteen degrees; whence it follows, that if the diff. of longitude, or arch of the equator, intercepted between the meridians, paſſing through any two places, be known; the difference of the times of the day in theſe two places is known alſo; conſequently the hour in one place being known, the hour in the other place is known alſo. And on the contrary, if the difference between the times of the ſun being on the meridian of any two places be known, the diff. of longitude between theſe two places is known alſo, by reducing the difference of the times into degrees and minutes, at the rate of fifteen degrees to one hour.

As all the meridians cut the equator at right angles, and from thence converge gradually, ſo as to meet in the two poles, it evidently follows, that the eaſting or weſting, in every different parallel of latitude will vary, from the equator to the poles. Hence it follows, that as we count the ſame number of degrees of longitude in every parallel of latitude, the miles that make a degree of longitude in every parallel of latitude, will be variable, from ſixty miles at the equator, to nothing at the poles.

The miles that make a degree in every, or in any, parallel of latitude, may be found by this anology.

As radius or ſine 90d. : 60m. at the equator : : the ſine comp. of any latitude : the miles that make a degree in that latitude.

This theorem is founded upon the direct proportion of the peripheries of circles to their radii, or ſemidiameters : and is the key to the ſeveral caſes of parallel ſailing, thus,

Caſe 1ſt. Having the parallel of latitude ſailed in, and the parallel diſtance, to find the difference of longitude, the proportion is,

As ſine comp. of the latitude : the parallel diſtance
: : radius : to the difference of longitude.

Caſe 2d. Having the diff. of longitude and latitude ſailed in ; to find the parallel diſtance, ſay,

As radius : the diff. of longitude
: : ſine comp. of latitude : parallel diſtance.

Caſe 3d. Having both diff. of longitude of two places, and the parallel diſtance given ; to find the latitude of that parallel, ſay,

As difference of longitude : radius
: : parallel diſtance : ſine comp. of latitude.
Which ſubtract from 90 degrees, leaves the latitude.

Caſe 4th. Having two latitudes, and the parallel diſtance in one given ; to find the parallel diſtance in the other latitude, ſay, As ſine comp. of the latitude in which the diſtance is given : that diſtance : : ſine comp. of the other latitude : the parallel diſtance in that other latitude.

Caſe 5th. Having two diſtances in two different parallels, and one latitude given ; to find the other latitude, ſay,

As the diſtance in the given lat. : ſine comp. of that lat. : : the diſtance in the required latitude : the ſine comp. of that latitude ; which being ſubtracted from 90 degrees, is the latitude required.

Thus we have gone through the ſix caſes of plain ſailing, and five of parallel ſailing ; the former of which are exactly ſimilar to the method of working by MERCATOR's CHARTS, which ſuppoſes the degrees of latitude to be protracted in the ſame ratio, as the degrees of longitude are diminiſhed, in their approaches towards the poles of the earth ; therefore this extenſion of the degrees of latitude, and conſequently of the difference of latitude, between any two places, is called the meridional diff. of latitude, and is found by taking the meridional parts, of any two places fron a table calculated for all parallels, and ſubtracting the leſſer from the greater number, if they are both ſituated north or both ſouth of the equator. But if one place be north and the other ſouth of the equator then their meridional diff. of latitude is found by adding their meridional parts, whence,

Caſe 1ſt. Having the latitudes and longitudes of two places given; to find the courſe, diſtance, and departure, ſay,

As meridional diff. of latitude : tangent of radius
: : diff. of longitude : tangent of the courſe.

2d. As the ſine comp. of courſe : real diff. of latitude
: : radius : the diſtance.

3d. As radius : diſtance : : ſine of courſe
: the departure.

Caſe 2d. Both latitudes, *viz.* that ſailing from, and that coming to, being given with courſe ; to find diſtance, departure, and the diff. of longitude.

1ſt. As ſine comp. of courſe : diff. of latitude
: : radius : the diſtance.

2d. As radius : the diſt, : : ſine of courſe : departure

3d. As tangent radius : meridonal diff. of latitude
: : tangent of courſe : diff. of longitude.

Caſe 3d. Both latitudes and diſtance ſailed, being given; to find direct courſe, and diff. of longitude,

As diſt. : radius : : diff. of lat. : ſine comp. of courſe, which ſubtract from 90 gives the courſe.

As ſine comp. of courſe : meridional diff. of latitude
: : ſine of courſe : the diff. of longitude.

Caſe 4th. Both latitudes, and departure given; to find courſe, diſtance, and diff. of longitude.

1ſt. As the real diff. of latitude : departure : : the meridional diff. of latitude : the diff. of longitude.

2d. As diff. of latitude : tangent of radius 45 deg.
: : the departure : tangent of the courſe.

3d. As ſine of courſe : departure : : radius : diſtance.

Caſe 5th. One latitude, courſe, and diſtance ſailed, given; to find the diff. of latitude and diff. of longitude.

As radius : the diſtance
: : ſine comp. of the courſe : diff. of latitude.

Hence it is eaſy to find the meridional diff. of latitude, and the proportion for the diff. of longitude, is,

As tangent radius : meridional diff. of latitude
: : tangent of the courſe : the diff. of longitude.

Caſe 6th. One latitude, courſe, and departure given; to find the other latitude, diſtance ſailed, and diff. of longitude.

1ſt. For the diſtance, the proportion is,

As ſine of courſe : departure : : radius : the diſtance.

2d. For the proper diff. of latitude, this anology,

As tangent of the courſe : departure : : tangent of radius
: the real diff. of latitude.

3d. For the diff. of longitude, this will do,

As tangent of radius : meridional diff. of latitude.
: : tangent of the courſe : diff. of longitude.

Caſe 7th. One latitude, diſtance ſailed, and departure given; to find the other latitude, courſe, and diff. of longitude.

1ſt. For the courſe, ſay,

As diſtance : radius : : departure : ſine of the courſe,

2d. For diff. of latitude, the analogy is thus,

As radius : diſtance : : ſine comp. of the courſe : diff. of latitude: whence the meridional diff. of latitude may be found.

3d. For the diff. of longitude, ſay,

As ſine comp. of the courſe : meridional diff. of latitude : : ſine of the courſe : the diff. of longitude.

Caſe 8th. One latitude courſe, and diff. of longitude given, to find the other latitude, and diſtance.

1ſt. For the enlarged diff. of latitude, ſay,

As tangent of the courſe : the difference of longitude : : tangent of radius : the meridional difference of latitude. Then applying the meridional difference of latitude to the meridional parts of the given latitude, we get the meridional parts of the required latitude correſponding, to which in the table of theſe parts take out the other latitude, by means whereof we obtain the real difference of latitude.

2d. For the direct diſtance ſailed it is,

As ſine compliment of the courſe : true diff. of latitude : : radius : the direct diſtance ſailed.

In the ſolution of all theſe problems of plain or mercator's ſailing, there is one univerſal axiom or fundamental truth, to which we may refer for ſtating the proportions according to art, *viz.* in all caſes, if either of the legs, (the diff. of latitude or departure) be made the radius of a circle; the other leg will be a tangent to its oppoſite angle, and the hypothenuſe or diſtance will be a ſecant, to that ſame angle.

But if the diſtance be made the radius of a circle, then will the legs be ſines of their oppoſite angles. A general rule to find a ſide, the proportion begins with an angle, but to find an angle, begin with a ſide.

Although this method, called MERCATOR's, of finding the diff. of longitude, correſponding to any two different latitudes, is more exact, yet we may not wholly neglect a practical method, which although not ſo ſtrictly true, will in many caſes of a day's run, not err above a mile, and that is deduced from parallel ſailing, called middle latitude.

The general proportion for the diff. of longitude, having both latitudes and departure given, is

As ſine comp. of middle latitude : departure : : radius
But if both latitude and longitude, of the place ſailed
: the diff. of longitude.
from, and bound to, be given, ſay thus,

1ſt. As radius : diff. of longitude : : ſine comp. of the middle latitude : the departure.

For courſe. As diff. of latitude : tangent of radius : : departure. : tangent of the courſe. Whence the diſtance is eaſily found.

N. B. The middle latitude is found by taking the half ſum of the two latitudes ; and its compliment, by ſubtracting that half ſum from 90 degrees.

To keep an account of a ſhip's longitude at ſea by dead reckoning, it will be neceſſary to premiſe, that we ſhall begin longitude at that meridian which paſſes through London ; and reckon to the weſtward, weſt longitude ; and to the eaſtward eaſt longitude, to 180 deg. where the two accounts meet in the meridian oppoſite to that of London. Hence in eaſt longitude ſailing to the eaſtward, and in weſt longitude ſailing to the weſtward, the diff. of longitude is an increment of longitude, and adds to the longitude of the place ſailed from, to get the longitude ſhip. But if the ſum of the longitude ſailed from, and the diff. of longitude exceed 180 degrees, you may ſubtract that overplus from 180, and the remainder is the longitude ſhip, contrary in quality to the longitude ſailed from.

Again in eaſt longitude ſailing weſtward, and in weſt longitude ſailing eaſtward, the diff. of longitude is a decrement, and ſubtracts from the longitude ſailed from, to get the longitude ſhip. But if the diff. of longitude exceeds the longitude ſailed from ; ſubtract the leſs from the greater, and the remainder is the longitude ſhip of a contrary quality to the longitude ſailed from, for in ſuch caſe you have croſſed the firſt meridian.

Having the longitudes of two places to find their diff. of longitude. If the places are both in eaſt or both in weſt longitude, ſubtract one from the other, and the difference is the diff. of longitude, but if one place be in eaſt and the other in weſt longitude, their ſum is the diff. of longitude if under 180 deg. if more than 180 deg. ſubtract it from 360 deg. and the remainder is the difference of longitude.

Before we conclude mercator's ſailing, it may not be improper to ſhew by what artifice MERCATOR or WRIGHT has augmented the meridian line in theſe charts, which is

As radius or ſine 90 deg. : the miles that make a degree of latitude at the equator *(viz)* 60 miles : : the ſecant of any latitude : the miles in a degree in that latitude.

Thus may a table of meridional parts be conſtructed to every degree of latitude from the equator as far as you pleaſe, by a continual or ſucceſſive addition of proportional ſecants, found to every degree, which we ſhall omit at this time.

Hence an account of a ſhip's way upon the ſeas, may be kept by means of courſe and diſtance, and the latitude and longitude found at any propoſed time, which method is abſolutely true in theory; but the practice is difficult from the following obvious reaſons *(viz)* the courſe can ſcarce be had to a quarter of a point; and the diſtance at beſt is a little uncertain, as a ſmall error cannot be eaſily diſcovered; alſo there may be currents unknown, that in many caſes cannot be tryed or determined, nor can the exact leeway that a ſhip makes many times be diſcovered to a quarter of a point; theſe things in conjunction with the variation of the magnetical compaſs ſteered by, make it extremely neceſſary to have recourſe to ſome other more infallible guide, as a check or regulator of the aforeſaid imperfections. This the induſtry of man has accompliſhed in reſpect to latitude, at ſea, by means of celeſtial obſervations of the ſun, when on the meridian.

So that various inſtruments have been contrived, and applied by artiſts, for getting, or taking the ſun's altitude above the horizon at mid-day, but none is equal to that curious and uſeful quadrant or rather octant, the invention of our Countryman Mr. HADLEY, called Hadley's Quadrant; which is now become of general utility on board all veſſels in the foreign trade, as by it the ſun's altitude may be found any day at noon, if you can but ſee the ſun, and a horizon, either to the northward or ſouthward.

Therefore, in order to underſtand the nature of obſervations of the ſun's meridian altitude, and the latitude thereon depending, it may be premiſed, that the elevation of the pole, is equal to the zenith diſtance of the equinox, and alſo equal to the latitude of the place. For if we conceive ourſelves at the equator, the equinox will be in the zenith, and both poles in the horizon. Then if we move northward or ſouthward, ten or twenty degrees, it is evident that we raiſe the north or ſouth pole, ten or twenty degrees, and at the ſame time our zenith receeds ten or twenty degrees from the equinox.

Whence

Whence it follows that when the ſun is in the equinox, his zenith diſtance upon the meridian of any place is the latitude of that place. But as this phenomenon happens only twice in one year, it becomes neceſſary to have recourſe to the ſun's declination at all other times, which is to be applied to the obſerved ſun's zenith diſtance, or compliment of the altitude on the meridian, to attain the latitude of that place. Thus,

1ſt. If the ſun be obſerved ſouthward, with ſouth declination, or northward with north declination, the equinox will be between the ſun and zenith; therefore ſubtract the declination from the obſerved zenith diſtance, and that difference is the latitude, contrary to the declination, with reſpect to north or ſouth.

2d. If the ſun be obſerved on the meridian ſouthward with north declination, or northward with ſouth declination, the ſun will be between the equinox and the zenith, therefore add the declination to the zenith diſtance, and that ſum is the latitude of the ſame name as the declination, with reſpect to north or ſouth.

3d. If the ſun be obſerved on the meridian northward, or ſouthward; when the declination exceeds the zenith diſtance, the zenith will then be between the ſun and equinox, and the difference of declination and zenith diſtance, is the latitude of the ſame name as the declination.

N. B. This third caſe can never happen but when you are between the tropics of CANCER and CAPRICORN, between the latitude 23 degrees and a half north, and 23 degrees and a half ſouth.

4th. It may happen that ſailing far north or far ſouth within the arctic or antarctic circles, that the ſun's meridian altitude, may be obſerved, when it does not ſet every twenty four hours, below or under the pole, then the equinox on that ſide is under the horizon you obſerve from, and the compliment of the ſun's declination added to the ſun's altitude ſo obſerved, is the latitude of the ſame name as the declination.

Theſe four, are all the variety that can happen, except the ſun ſhould be obſerved in the zenith, and then the latitude is equal to the ſun's declination north or ſouth, according to the ſeaſon. The two firſt caſes are general, the third and fourth are peculiar to the torrid and frigid zones only.

Since the Sun's declination is ſo extenſively uſeful in obtaining the latitude, by obſervation; it is to be found in many annual productions called almanacks; and in books of Navigation done by various authors, yet that our young navigator may not be totally ignorant of the ſun's declination, what it is, and how to find it, we ſhall ſubjoin the following remarks.

1ſt. The ſun's declination is its diſtance from the equator in degrees and minutes, and can never exceed 23 deg. 29 min. north or ſouth.

2d. The ſun's declination is north increaſing from March 21ſt. to June 21ſt. then it is north decreaſing till September the 22d. then its declination is ſouth increaſing till December the 21ſt. and from that time it is ſouth decreaſing till March the 21ſt.

3d. The ſun's declination depends entirely on his place in the ecliptic, ſo that in the firſt of Aries it is 0. then increaſes thro' Aries, Taurus, and Gimini, being 23 deg. 29 min. north, when in the firſt ſcruple of Cancer, then it decreaſes as it apparently paſſes thro' Cancer, Leo, and Virgo. Its declination is again 0, when it enters Libra, hence the declination becomes ſouth, increaſing as it apparently paſſes thro' Libra, Scorpio, and Sagitarius; being 23 deg. 29 min. ſouth, when it enters the tropical ſign Capricornus, then it decreaſes as it appears to paſs through Capricornus, Aquarius, and Piscies.

4th. The ſun enters Aries, March the 20th. or 21ſt. Taurus April 20th. Gimini May 21ſt. Cancer June 21ſt. Leo July 23d. Virgo Auguſt 23d. Libra September 23d. Scorpio October 23d. Sagitarius November 22d. Capricornus December 21ſt. Aquarius January 20th. Piscies February 19th.

5th. Whence the ſun's place is eaſily found for any time propoſed; by taking the difference between the propoſed day, and the day of the ſun's entrance into the ſign of that month; and note if the propoſed day be greater, that difference is the degree of the ſun's place in that ſign, but if leſs, the compliment of that difference to 30 is the degree of the ſun's place in the preceeding ſign. Thus, if the ſun's place were required the 29th. of May. As the ſun enters Gimini the 21ſt. 29—21=8 ∵ the ſun's place is Gimini 8 degrees, again if the ſun's place were required the 12 of Auguſt, as the ſun enters Virgo Auguſt the 23d. it follows that 23—12=11, and 30—11=19 ∵ the ſun's place is in the preceeding ſign *viz.* in Leo 19 deg. which was required,

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6th. Having thus previouſly found the ſun's place any day; the following analogy gives the ſun's declination. As radius : ſine of the ſun's diſtance from the neareſt equinoctial point Aries or Libra : : ſine of the ſun's greateſt declination : the ſine of his preſent declination at the time propoſed.

7th. We have heretofore obſerved, and given rules to find the latitude at ſea, by applying the ſun's declination to the obſerved zenith diſtance, or ſun's meridian altitude, which rules would be accurately true if the obſervations were made in or near the meridian, for which your tables of declination were calculated,

8th. But as our navigator may happen to be much to the eaſtward or weſtward, we think, we have a right as our duty to apprize him of a conſiderable error in uſing thoſe tabular declinations, and the farther from the meridian, the greater is the error, which may poſſibly amount to 10 or 12 miles in ſome caſes.

9th. The pointing out an error, plainly infers the neceſſity of a correction, which may be thus effected at any time when you obſerve, in any place of the globe.

10th. To correct the ſun's declination, to any remote longitude eaſt or weſt, take out of your tables of the ſun's declination, the daily difference of declination at that time. Then ſay,

11th. As 360 degrees : daily difference of declination : : the longitude in, reckoned from the meridian of your tables : a proportional part of declination.

12th. This proportional part thus found is ſometimes an increment and augments the declination, and ſometimes it is a decrement and diminiſhes the declination, as follows,

13th. In weſt longitude with declination increaſing, and in eaſt longitude with declination decreaſing, the proportional part is an increment, and adds to the declination of that day in your tables to obtain the corrected declination to that longitude.

4th. In weſt longitude with declination decreaſing, and in eaſt longitude with the declination increaſing, the proportional part is a decrement, and ſubtracts from the tabular declination of that day to obtain, the declination corrected to that longitude.

Here we ſhall remind our young obſerver that in order to obſerve with accuracy the ſun's meridian altitude.

That the height of the eye of the obſerver above the ſurface of the ſea makes the obſerved altitude a little too great, as in the following order.

If the height of the eye be … the error is

feet.	min.
3	2
6	3
11	4
17	5
25	6
34	7
44	8

Therefore theſe numbers are to be deducted from the obſerved altitudes in the fore obſervation, to get the true altitudes, as to that part.

As it is moſt convenient, when exactneſs is required in obſerving the ſun's altitude, to obſerve the under or upper limb of the ſun touching the edge of the ſea in the horizon, then in the former caſe, the ſun's ſemidiameter, or ſixteen minutes is to be added, and in the latter to be ſubtracted from the obſerved altitude, to have the true altitude of the ſun's center in that reſpect.

Again, another correction of the ſun's obſerved altitude ariſes by reaſon of refraction of the rays of light in their paſſage through the atmoſphere, or body of air ſurounding the globe, by which all diſtant objects, as the ſun, moon, &c. are made to appear higher above the horizon than what they really are; whence the altitude taken by the quadrant is called the apparent altitude, and muſt have the refraction ſubtracted from it, to produce the true altitude.

N. B. Of all refractions the horizontal will be greateſt, for refraction gradually decreaſes from the horizon to the zenith, where it entirely vaniſhes, or ceaſes to exiſt.

The refraction angles to be allowed at the ſeveral altitudes of the ſun, are,
The horizontal refraction 33 minutes.

Sun's apparent altitude in degrees. … refraction is

D.	M.
1	24
2	18
3	14
4	11
5	9
6	8
8	6
12	4
16	3
23	2
40	1

An example will make the aforegoing deductions plain and clear.

Suppoſe the ſun's meridian altitude be obſerved 40 feet above the ſea, by its upper limb, 38 deg. 37 min. query the true altitude after all deductions?

	d.	m.
1ſt. The apparent altitude - - - - -	38	37
height of the eye 40 feet dip ſubtract - - - -		8
difference - - - - - - - - - - - - -	38	29
refraction at 38d. 37m. ſubtract - - - - - -		1
	38	28
ſun's ſemidiameter ſubtract - - - - - - - - -		16
the ſun's true altitude - - - - - - - - -	38	12

What is meant by refraction, may partly be illuſtrated, by that familiar experiment, of a baſon with a flower in its bottom, and water poured upon it. Thus,

Set the empty baſon upon a table or ſtand, and if the ſpectators look into the baſon, then each withdrawing, ſo that they inſtantly looſe ſight of the flower on the bottom by the interpoſition of the ſide or brim of the baſon, whence directing all to reſt ſteadily, let water be poured into the baſon, and every obſerver will inſtantly ſee, the flower and the bottom of the baſon, apparently raiſed by refraction of the rays of light paſſing through a medium (as water) of a different denſity from air. Laſtly, there is another optical defect attending the apparent altitude of objects above the horizon, taken by an inſtrument, and that is the parallax, or the difference between the apparent place of an object viewed from the earth's ſurface; and its real place, if viewed from the earth's centre, the effect of parallax like that of refraction is greateſt in the horizon, and vaniſhes in the zenith; but their effects are in other reſpects contrary, for objects are raiſed higher than their true place by refraction, and depreſſed lower than their true place by parallax, but the ſun's parallax is too ſmall, by reaſon of his great diſtance from the earth, to affect his altitude, in an obſervation thereof for the latitude.

But parallax conſiderably affects the altitude of the moon, near the horizon, by reaſon of her nearer diſtance to the earth, than that of the ſun; ſo that her horizontal parallax is ſometimes more than a degree.

N. B. If you obſerve in the night by a known ſtar; the rules are the ſame for applying the ſtar's declination; to its zenith diſtance, to obtain the latitude; alſo the ſtar's declinations vary little in an age.

There is an imperfection in all magnetical compaſſes, called by navigators the variation. For altho' the compaſs in its greateſt perfection, has, by means of the magnetical virtue a certain tendency northward; yet in moſt places there is a ſenſible deviation from true north; ſo that there of courſe ariſes a diſtinction between the true and magnetical north, and this diſtinction extends itſelf to all the other points of the compaſs.

The variation of the compaſs is in ſome places weſtward, and in others eaſtward, that is the north point of the compaſs in ſome places ſettles, or when at reſt, points to the weſtward of the true north point of the horizon; then it is ſaid to have weſt variation there; which is the preſent caſe in the britiſh channel, and over moſt part of the atlantic ocean. But when the north point of the compaſs ſteered by, ſettles or points to the eaſtward of true north, then it has eaſt variation; and this was the caſe here, about two centuries ago.

Hence it appears that the variation of the compaſs, is not only different in different places, but alſo variable at the ſame place at different times; yet there are ſeveral infallible methods of finding it in any place at any time; either by land or ſea. The moſt practical method at ſea is by an amplitude of the ſun at riſing or ſetting.

The ſun's true amplitude at riſing or ſetting, is an arch of the horizon contained between the ſun at riſing or ſetting, and the eaſt or weſt point of the horizon; and may be found by the following analogy.

As ſine compliment of the latitude : radius or ſine 90 deg. : : ſine of the ſun's declination : the ſine of the ſun's true amplitude, which amplitude is north or ſouth from eaſt or weſt according as the declination is north or ſouth.

The magnetical amplitude is alſo an arch of the horizon contained between the ſun at his riſing or ſetting, and the eaſt or weſt point of the compaſs ſteered by; and may be found in the morning or evening, when the ſun is about five or ſix degrees high, with an azimuth compaſs.

Then note, that if the two amplitudes agree, which is but ſeldom, there is in that place, at that time, no variation.

But if they differ, as will often happen, that difference rightly counted is the true variation. Therefore, The two amplitudes being found, reckon both from the north, then the rule is,

At ſun riſing $\left\{\begin{matrix}\text{True}\\ \text{Magnetical}\end{matrix}\right\}$ amplitude greateſt the variation is $\left\{\begin{matrix}\text{East}\\ \text{West}\end{matrix}\right\}$ but at the ſun ſetting, it is $\left\{\begin{matrix}\text{West,}\\ \text{East.}\end{matrix}\right.$

It follows now that we inform our young navigator, how to caſt the variation, and aſſign the true courſe from the compaſs courſe. In order to which you muſt reckon your courſes in the N W and N E quarters, from the north, and in the S W and S E quarters from the ſouth.

Then if you ſail into the N W or S E quarters, with weſt variation, add the variation to the compaſs courſe; but if you ſail into the N E or S W quarters, ſubtract the variation from the compaſs courſe, and you will obtain the true courſe.

But if you ſail into N W or S E quarters with eaſt variation ſubtract the variation from the compaſs courſe, and, ſailing into the N E or S W quarters, add the variation to the compaſs courſe for the true courſe.

Or by the following method you may eaſily allow for the variation. Thus,

In weſt variation, looking forward towards the ſhip's head, the variation goes to the left hand, and the true courſe is to the left hand of the compaſs courſe; but in eaſt variation it is juſt the contrary.

Again having the true courſe given to find the compaſs courſe. Variation weſt adds to the true courſe in the north eaſt and ſouth weſt quarters, and ſubtracts in the north weſt and ſouth eaſt quarters, eaſt variation juſt the contrary, or in weſt variation the true courſe is to the right hand of the compaſs courſe; but in eaſt variation it is to the left.

N. B. If you obſerve carefully by an azimuth compaſs what point or degree the ſun is upon at mid day when you have the beſt altitude on your quadrant; the degrees on the compaſs between the ſouth, and that point the ſun is on, is the variation, weſt if the ſun be to the weſtward of the magnetical meridian; but eaſt if the ſun be to the eaſtward of the ſaid meridian.

The variation of the compaſs may be thus found at ſea, independent of both latitude and declination.

Take with your quadrant the ſun's altitude at any time in the forenoon, when it is under 30 degrees high, which note down, and let an aſſiſtant at the ſame time note the ſun's azimuth, or point of bearing from the ſouth in degrees and minutes, or points and quarters, which alſo note down, then in the afternoon obſevre with your quadrant when the ſun is the ſame height; your aſſiſtant then alſo noting down the points and quarters of the ſun's azimuth or bearing from the ſouth, then as it is evident that the ſun at noon or mid day was on the middle point, between the morning and evening azimuths, therefore the diſtance of that point from ſouth by your compaſs is the variation, weſt if the middle point be in the ſouth weſt quarter, but eaſt when that point is in the ſouth eaſt quarter, thus if the ſun ſhould be obſerved ſouth eaſt in the forenoon, with 20 degrees altitude, and that ſame day in the afternoon be obſerved weſt ſouth weſt with the ſame altitude, then the arch intercepted between the two obſervations is 10 points, the middle point is 5 from each, and that makes ſouth by weſt for the ſun's azimuth that day at noon, or when his altitude was the greateſt; hence the variation there is one point weſt, as the middle point falls in the ſouth weſt quarter.

As it often happens at ſea that the courſe a ſhip lies up too, is not her true courſe by reaſon of the leeway or fall the ſhip makes when cloſe hauled, or upon a wind, and this fall or leeway is variable, according to the force of the wind; ſo that when the breeze will allow you to carry all ſails, and the ſhip lies up to ſix points from the wind, the fall or leeway will be one point; if it blows ſo hard as to take in the ſmall ſails, then the leeway is one point and a half, when it blows ſo hard as to reef topſails, its common to allow two points leeway; both topſails in and a ſea three points leeway; as the gale grows voilent ſo that you are obliged to troy under a main ſail and a mizen, there will be four points leeway; under a main ſail only, five points; under a mizen only, ſix points; and if you lie a hull, all ſails furled, the uſual allowance is ſeven points leeway. If the leeway and variation both go to one ſide, you allow their ſum; but if they go againſt other, or to contrary ſides, if they be equal they balance, and the courſe ſteered is the courſe made good; if they be unequal, you allow their difference to the ſide that the greater part goes to.

If your ſtation on board of a veſſel bound to a foreign port, be ſuch as may require you to keep an account of the ſhip's way, or if you are inclined to do it for your own ſatisfaction, amuſement, or inſtruction; it will be neceſſary to have log-lines properly divided, with ſufficient length of ſtray line, a number of logs, and ſeveral half minute glaſſes, a log-board, ſcale and compaſſes, or Gunter's ſliding rule, and a book with a good traverſe table; a good chart of the coaſt you ſail from, and of that you are bound to; alſo a book properly ruled, and fitted for your ſea journal.

If you intend to heave the log every hour, one page of a quarto book will hold one day's work, but if you heave the log but once in two hours, as is the practice out of *Whitehaven*, one page of a quarto book will hold two days work. The firſt column on the left hand ſide of every page is for hours, the ſecond for the courſes, the third for knots, the fourth half knots, the fifth for winds, and the reſt of the page for tranſactions or remarkable occurrences. Alſo you muſt obſerve between the firſt and ſecond day's work on each page to rule out two lines acroſs the page, and theſe are to be divided thus, the firſt to the left hand ſide is for courſe correct, the ſecond for diſtance that day, the third for the northing, fourth for ſouthing, fifth for eaſting, ſixth for weſting, ſeventh for latitude per account, eighth for departure, ninth for diff. of longitude, and the tenth for longitude ſhip.

Being thus prepared, when you know the latitude and longitude of that cape, headland, port, or iſland, that you are to take your departure from; and alſo the latitude, and longitude of the cape, headland, or port, you are bound to; if you are bound from Europe to America, you may compute your courſe, diſtance and departure, then ſpread before you a good mercator's chart of the ocean between the two ports; and by laying a ruler over the two ports, you will ſee how your computed courſe agrees with the draught; and alſo you muſt carefully obſerve if there be any iſlands, banks, or rocks in your courſe from port to port, and if no land o other impediment interfere to obſtruct your paſſage, yo may make bold to ſteer your true courſe, but if you find b your chart that land, iſlands, rocks, or banks, lie in yo courſe, then you muſt ſhift your ruler, keeping one end cloſ to the port ſailed from, moving the other part clear of a iſlands, rocks, banks, &c. obſerving carefully, by your cha what courſe will carry you, clear of the iſlands &c. regardi the latitude and longitude of ſome point in that courſe, breaſt of the iſland, &c. then you may ſteer that courſe un you get into the latitude and longitude of that point obſerve ſo proceeding from thence to your intended port, or to the next latitude and longitude that you apprehend it neceſſary to ſail to, and by this method you muſt proceed until you arrive at your deſigned port.

But it frequently happens, that at ſea you cannot keep the ſhip to your known courſe, by reaſon of contrary winds; ſo that, it becomes abſolutely neceſſary to know at all times what way you ſail, and how far on every different courſe, both when you can ſtand on your true courſe, and when you are obliged to deviate from it by contrary winds, hence it becomes expedient once in twenty four hours, or oftner, to reduce the ſeveral courſes and diſtances to one, and the time for that purpoſe is arbitrary, yet the generality of navigators have (not without good reaſon) fixed upon mid day for the time of regulating, adjuſting, and determining by the rules of art, what courſe they have in twenty four hours made good, what diſtance run, what latitude and longitude the ſhip is in per account, ſo that the Navigator is thereby enabled to prick the ſhip then on his chart, and thence he can diſcover, what courſe he ought then ſteer, if wind and weather permit.

N. B. It is, notwithſtanding all you can do by account, abſolutely neceſſary to obſerve the ſun's altitude every day at noon, if the weather allow it, to get the latitude ſhip, and if your obſervation be well made, you are to prefer the obſerved latitude for the latitude in; rather than the latitude per account. Having laid down theſe neceſſary precognitæ, we ſhall proceed to ſhew our young navigator, after what manner a days work of a ſhip's motion is to be wrought and reduced to order, as practice is ever a little different from Theory. Therefore we ſhall ſuppoſe it noon, and that we took our departure from cape Clear yeſterday at two in the afternoon; at that time having the cape bearing, ſouth ſouth eaſt about ſix leagues by diſtant eſtimation.

Then put down the ſhip's bearing and diſtance from the cape; with proper allowance for variation, as has been directed; and under that bearing, put down every courſe ſteered from your log board with due allowance for variation, and leeway, when the ſhip is cloſe hauled upon a wind, as has been directed a priori.

N. B. If the log has been hove, only every two hours, you muſt double the knots and half knots, on every courſe for the diſtance run on that courſe in miles.

Then, extend from the ſine of eight points the radius, to the firſt diſtance, and that extent ſet upon the ſine of the rhumb or point of the courſe, after allowing for variation and lee-way, gives the departure eaſt or weſt as per courſe, and the ſame extent ſet upon the compliment of the courſe on the line of ſines of rhumbs gives (where the other foot falls) the diff. of latitude north or ſouth as per courſe; to be put under their reſpective letters, as in traverſe ſailing, and thus you proceed with all the courſes and diſtances of that day's run, obſerving carefully to place every reſpective departure, and diff. of latitude, under its proper title, as your courſe always directs.

N. B. If the courſe be north or ſouth the diſtance is all diff. of latitude, if eaſt or weſt it is all departure no extending, Then ſum up all your northings, ſouthings, eaſtings, and weſtings ſeperately; and the difference of your northings and ſouthings, is your diff. of latitude, if you have that day ſailed both northerly and ſoutherly, but if you have only northing or only ſouthing, that itſelf is your diff. of latitude according to its title, and the difference of eaſting and weſting is your departure, according to the title of the greater part, if you have ſailed that day both eaſterly and weſterly; but if you have only eaſting or weſting that itſelf is your departure (and thus you have reduced your day's work to one diff. of latitude, and one departure, with which you find courſe made good, and diſtance run, as directed in plain ſailing.

Then you apply your diff. of latitude to the latitude of the cape; for the latitude ſhip, and after the firſt day's work, you apply your diff. of latitude to the latitude ſhip the day before, for the latitude ſhip that day, but if you have a good obſervation and the obſerved, latitude differ but two or three miles from the latitude per account, you may quit your latitude per account, and prefer the obſerved latitude for the latitude ſhip at that time.

Then half ſum of your two latitudes ſubtracted from 90 deg. gives the compliment of the middle latitude, and the extent from ſine compliment of midde latitude, to radius 90 deg. ſet on the departure increaſing, always gives the diff. of longitude, which muſt be applied to the longitude of the cape; and you get the longitude ſhip, at that time; but after the firſt day's work, you apply your diff. of longitude in degrees and minutes, to the longitude of the day before for longitude ſhip. Then placing every article in its proper column, your day's work is finiſhed, and thus you proceed to the end of your voyage.

It is cuſtomary, to carry on the ſum of the daily departures; which ſum is nearly equal to the meridian diſtance, in ſome caſes.

If after being ſome time at ſea, you ſhould be put from your courſe by contrary winds, when the wind comes fair, you may at any time diſcover your courſe from the place you are in; to the port bound to.

For, you have for that purpoſe, the latitude and longitude ſhip : with the latitude and longitude of the port bound to; whence by middle latitude, extend from the ſine compliment of middle latitude to radius 90 deg. and that extent ſet on the difference of longitude reaches to the departure always decreaſing, then the extent from the diff. of latitude in miles to the departure, ſet on tangent of radius 45 deg. gives the tangent of the courſe under or above four points, as the departure is leſs or more than the difference of latitude, and thus you may find your courſe any at time; which you may prove by your chart, firſt pricking down the place of the ſhip, as has been hinted before.

Here it will be neceſſary to remind our young navigator, that if at ſea his latitude by account, and latitude by obſervation diſagree, and that difference amount to more than half a degree, he muſt conclude there is ſome error. therefore,

1ſt. Let him examine carefully all his work, and ſee that all be right, by examining his allowances for leeway and variation; then conſider the ſetting of the ſea; for if a ſtrong wind has ſtood a good while one way, he may be aſſured, a current ſets more or leſs that way, conſequently ought not to be neglected.

2d. If there be little wind and a ſmooth ſea, he may ſink (out of a boat at a ſmall diſtance from the ſhip, where the current is) an iron pot or kettle below the current with a line made faſt to it 60, 70, 80, 90, 100, or more fathoms in length, to be veered out into the ſea at one end, to give the ſinker depth enough below the current, and then the end of the line in hand faſtened to the boat's ſtern, to bring her up as if at anchor, to keep her as ſteady as poſſible upon the top of the current.

3d. Then heave your log over board, turn your half minute glaſs, and obſerve by your compaſs, to ſet the drift of the log upon the current, while the half minute glaſs runs ont, the line run of the reel will give you the velocity of the current, or number of miles it runs per hour, to which you may add a fourth more or leſs, for the drift of the boat, with the current according to the depth of water, weight or capacity of the ſinker, to keep the boat more or leſs ſteady, thus the direction of the line being ſet by the compaſs, ſhews to what point the current ſets.

4th. If there be ſufficient reaſon to judge that a current is the cauſe of the error, which is often the caſe, having found its courſe or direction but not its quantity, the departure may be corrected thus,

As radius : correction in latitude : : tangent of the currents courſe : correction in departure, which is to be reckoned eaſt or weſt as the currents motion, then by this the departure will be corrected to agree with the obſerved latitude.

5th. If the variation be found erroneous, by having the error of variation, you may find the correction in latitude and departure thus. Judge as near as you can how long the variation has been wrong accounted, or if your reaſon inform you it has been altering gradually, ever ſince your laſt agreement of latitude by account and by obſervation, in ſuch caſe you may take the departure correſponding to half that time, and ſay as radius : that departure : : ſine of the error of variation : the correction in latitude.

And as radius : difference of latitude : : ſine of the error of variation : the correction in departure.

6th. Lay a ruler over the compaſs in the place of the true meridian, and to ſhow the error of variation, then if the ſhip is farther from this meridian, than it was before from the ſuppoſed meridian, the correction in departure muſt be added to the former departure, but if nearer the correction of latitude muſt be added to the former difference of latitude; and when one adds, the other always ſubtracts, becauſe they are always contrary.

7th. If after all theſe things are reviewed, the latitudes cannot be made agree, there is ſtill ſome error either in the courſe, diſtance, or both, which muſt be corrected.

8th. Obſerve whether the ſhip has outrun the reckoning, or the reckoning has outrun the ſhip, alſo conſider your courſe from the time of laſt obſervation, whether it is leſs or more than four points from the meridian; that is, whether the difference of latitude, or departure be greater.

9th. If the difference of latitude be greater, it is highly probable the error is in the diſtance ſailed, therefore ,with the difference of latitude and departure made ſince the time of laſt obſervation, ſay

As difference of latitude : departure : : the error in latitude : the correction in departure, which add to the departure when the ſhip is foremoſt, but ſubtract when the reckoning is foremoſt, for in this caſe they both add or both ſubtract. If your courſe be more than four points from the meridian, or departure greater, the error is moſt likely to be in the departure, therefore ſay,

As the departure : difference of latitude : : error in latitude : the correction in departure, which adds to the departure when the reckoning is foremoſt, but ſubtract when the ſhip is foremoſt, for in this caſe one adds the other ſubtract, being always contrary, but if you ſail near eaſt or weſt, this correction will be unneceſſary.

If the courſe be near four points from the meridian, and you have reaſon to ſuſpect either courſe or diſtance, it is beſt you correct them both, but if it be doubtful which is the courſe in the error, correct only the latitude, and the departure, for if they both be faulty, their corrections will be contrary, and conſequently deſtroy one another's effects.

To correct the longitude, take the meridional difference between the reckoning, and obſerved latitude, then ſay,

As the error in latitude : the correction in departure : : meridional difference of latitude : the correction in longitude, which is to be applied the ſame way eaſt or weſt, as was the correction in departure.

Or if you would correct the longitude by middle latitude, add the reckoning, and obſerved latitudes together, and ſubtract half that ſum from 90 degrees, which gives the compliment of middle latitude, then ſay.

As ſine compliment of middle latitude : correction in departure : : radius or ſine 90 : the correction in longitude.

14th. The error in the courſe may arriſe from bad ſteerage, incorrect leeway, or not allowing right for variation, or from the ſetting of unknown currents, tides, &c. for although the rules heretofore ſet down for leeway according to ſail carried, are the uſual allowances, yet notwithſtanding every artiſt ought by experiment, to be well acquainted with the leeway his ſhip makes, under all the various circumſtances of ſail abroad. As different ſhips make different leeway under like ſail; as will the ſame ſhip ſometimes according to her different trim with reſpect to loading, &c.

15th. The error in the diſtance may ariſe from the inaccurate meaſuring the way of the ſhip by the log, or by an error in the half minute glaſſes, which may be examined by hanging up a line and plummet 39, 2 inches long, reckoning from the centre of the ball, to the point of ſuſpenſion, it will vibrate 30 times in one glaſs if it be true, that is, ſuch a ball hung up and put in motion, will vibrate juſt in a ſecond of time, and if the glaſs runs out while 30 ſwings or vibrations are made paſt the perpendicular, the glaſs is true otherwiſe not, another proof is by one already proved.

16th. In ſtrictneſs each knot ſhould be nearly 51 feet aſunder, agreeing neareſt with the 120th. part of the 60th. part of a degree of a great circle, or a mile, but the log dragging ſomewhat after the ſhip, meaſures her diſtance this way leſs than it is, and therefore the leſs diviſions of 45 and 46 feet between knot and knot, are found to agree beſt with practice. alſo in the ſea phraſe, it is better for the reckoning to be a head of the ſhip, than for the ſhip to be a head of the reckoning; that is, its better to look out for land a little too ſoon, than to be aſhore before it be expected.

In caſe, our young navigator ſhould happen to be abroad for upwards of twelve months, he may be at a loſs to know the moon's age and her ſouthing, for want of an almanac, therefore it is neceſſary that he ſhould know how to find the epact (or age of the moon, the beginning of the new year,) with the number belonging to each month, to find the mean lunations as full and change; with the moon's age, and ſouthing, as follows.

For the golden number any year, add one to the propoſed year of account, and divide by 19, and the remainder, is the golden number; for the golden number encreaſes 1 every year regularly and ſucceſſively until it come to 19, and then begins a new at 1. For the epact, multiply the golden number by 11 and divide by 30, and from the remainder ſubtract 11 if you can; and that remainder is the epact: if your remainder be leſs than 11, you muſt borrow 30 to it, and then ſubtract 11 therefrom, and what remains is the epact.

If you add 11 to the epact of any year, that ſum if under 30, or the overplus if above 30 is the epact for the next or following year.

For the new moons, there are certain numbers for each month to be obſerved, as January 0, February 2, March 1, April 2, May 3, June 4, July 5, Auguſt 6, September and October 8, November and December 10. Hence for the new moon any month, to the number of that month add the epact for the year, which ſum ſubtract from 30 if you can, or from 59, and the remainder is the day of mean new moon.

To find the day of full moon, you muſt ſubtract the ſum of the epact and number of the month, from 15 if you can or from 45 and the remainder is the day of mean full moon.

If you would know the moon's age any day, you muſt collect the epact, number of the month, and day of the month into one ſum, which is the moon's age if under 30, if that ſum exceed 30, that exceſs or overplus is the moon's age, that day.

For the moon's ſouthing, multiply the moon's age if under 15, or the overplus if above 15 by 8, and the units figure of that product by 6, then the laſt product is minutes, and the tens figure of the firſt product is hours; and both is the time of ſouthing, in the afternoon if the moon is under 15 days old, but in the morning when her age is above 15 days.

To find the time of high water, at any place mentioned in your tide table, to the hour and minute in your table, add the time of moon's ſouthing that day, and that ſum if under 12, or the overplus if above 12, is the time of high water that day there.

But, as our navigator may be in ſuch latitude as an almanac or diary, although in itſelf ever ſo correct, may be of no ſervice to him with reſpect to the ſun's riſing and ſetting; or he may be abroad until that he carried from home with him is ſuper-annuated, and rendered of no uſe; therefore we ſhall inſtruct him, how to find the time of ſun riſing, and ſetting in any place, having the latitude of that place, and the ſun's declination (which we have ſhewn a priori, how to find.) But it muſt firſt be premiſed, that when the ſun is in the equator on the 21ſt. of March, and about the 22d. of September, it has then neither declination nor amplitude, and conſequently riſes at ſix o' clock due eaſt, and ſets at ſix due weſt, all through the two temperate and torrid zones, and at all other times, the time of riſing and ſetting differs from ſix o' clock; and this difference, is called the aſcenſional difference, which difference is always regulated by the latitude of the place, and ſun's declination at that time, as in the following proportion *(viz.)*

As radius : tangent of the latitude : : tangent of the ſun's declination : the ſine of the aſcenſional difference, which converted into time, allowing 15 deg. to one hour, gives the aſcenſional difference in time; then in north latitude when the ſun is in ARIES, TAURUS, GEMINI, CANCER, LEO, or VIRGO, the aſcenſional diff. ſubtracts from ſix o' clock, to find the time of ſun riſing; and adds to ſix for the time of ſun ſetting; but when the ſun is in LIBRA, SCORPIO, SAGITTARIUS, CAPRICORN, AQUARIUS, or PISCES, the ſaid difference adds to ſix, for the time of ſun riſing, and ſubtracts from ſix, for the time of ſun ſetting; and in ſouth latitude, the rules are to be reverſed, ſo that when the ſun is in northern ſigns, the aſcenſional difference in time adds to ſix o' clock, for the time of ſun riſing, and ſubtracts from ſix for the time of ſun ſetting; but when the ſun is in ſouthern ſigns, the ſaid difference ſubtracts from ſix for ſun riſing, and adds to ſix for the hour of ſun ſetting; and in all places, twice the hour of ſun riſing, is the length of the night, including twilight; and twice the hour of ſun ſetting, is the length of the day, excluſive of twilight; which is in general about two hours in the morning, and two in the evening, but varies a little in different latitudes, and in the ſame latitude at different ſeaſons of the year.

Here, we muſt let our young navigator know that the inhabitants of this terraqueous globe, are divided into three diſtinct claſſes *(viz)* Antoeci, Periœci, and Antipodes.

The Antoeci, with reſpect to ſituation, live upon the ſame meridian, but in oppoſite parallels of latitude, whence, they are equally diſtant from the equator or line, but on different ſides, that is one in north, and the other in ſouth latitude; they have the ſame elevation of the pole, but not the ſame pole; for as much as the north pole is elevated to one, the other has a like elevation of the ſouth pole; it is midday and midnight to both at the ſame time, their ſeaſons of the year are contrary, winter to one when ſummer to the other, the length of the day in one place, is juſt equal to the length of the night in the other, including twilight in the night; but if the two places are within the torrid zone, the variety of ſeaſons is but ſmall, and the length of days and nights near an equallity.

The Perioeci, are ſuch inhabitants of the earth, as live in the ſame parallel of latitude, but on oppoſite ſemicircles of the meridian, ſo that although they are equally diſtant from the equator on the ſame ſide, their difference of longitude is 180 deg. the ſame pole is equally elevated to both, it is midday at one place, when it is midnight to the other, their days and nights are of equal length, and they enjoy ſimilar ſeaſons of the year, at the ſame time, whether ſpring, ſummer, autumn, or winter.

The Antipodes, are ſuch as inhabit oppoſite meridians or circles of longitude, and on oppoſite parallels of latitude. Hence they are equally diſtant from the equator or line, but on different ſides, conſequently in different latitudes, again they have the ſame elevation of the pole, but not the ſame pole; their difference of longitude is 180 deg. it is winter to one, when ſummer to the other; conſequently the length of the day in one place, is juſt equal to the length of the night in the other at all times of the year; alſo when it is midday to one place, it is mid night at the other, further, if the two places are near the line their ſeaſons do not differ much; nor do their days and nights vary much in length.

That our young navigator may not be wholly ignorant of the true ſyſtem of the world, introduced of old by PYTHAGORAS and his followers, and revived of late by one NICHOLAUS COPERNICUS, but laſtly proved and demonſtrated by the late incomparable Sir ISAAC NEWTON. In which ſyſtem, the ſun is held to be much the largeſt of all the heavenly bodies, and is placed in or near the center of the planets; with a rotation about its axis in about 25 or 26 days, this great and glorious body is the fountain of light and heat, whoſe genial influence, invigorates and cheriſhes both the animal and vegetable ſpecies, by its inexhauſtible ſtore.

The firſt planet in order and next to the ſun, in reſpect to diſtance is Mercury, at the diſtance of 32 milions of miles; this planet is carried round the ſun in about 88 days of our time, is ſeldom ſeen by reaſon of his ſmall diſtance therefrom; being never more than 23 degrees elongated from the ſun.

The next planet in the ſyſtem to Mercury is Venus, at the diſtance of 59 milions of miles, performs its periodical revolution round the ſun in 224 days and three fourths of our time nearly, this is a bright and lucid ſtar equal in appearance to one of the firſt magnitude; is never elongated from the ſun more than 48 degrees, is ſometimes a morning, and ſometimes an evening ſtar, this planet viewed through a good teleſcope, is ſeen to vary its phaſes as doth the moon. Mercury and Venus, are called inferior planets, becauſe their orbits are included within the orbit of the earth.

The earth is the next planet in the ſyſtem, diſtant from the ſun 81 milions of miles, is urged round the ſun once a year, with its axis always parallel to its ſelf; and inclined to the ecliptic at an angle of 67 deg. 31 min. on which depends all the viciſſitude of ſeaſons, Spring, Summer, Autumn, and Winter, with all that variety of length of days in all latitudes; at the ſame time turning on its axis, once in 24 hours, conſtituting day on that ſide toward the ſun, and night on the oppoſite ſide, on this motion alſo depend, the two tides of flood, and ebb each day. The earth alſo has the moon in its annual tour round the ſun attending it, and reſpecting it as the centre of its motion, about which it revolves once a month, at the diſtance of about 240 thouſand miles; this attendant on the earth receives its light, luſture or brightneſs from the ſun, and tranſmits it to the earth by reflexion; as is evident from its increaſe and wane; and alſo from its dark appearance when eclipſed, or deprived of the ſun's light.

Next to the earth and moon is Mars, at the diſtance of 123 milions of miles from the ſun, who finiſhes his revolution round it, in 687 days our time nearly; the magnitude of this planet is apparently very variable, owing to its variable diſtance from the earth, being at one time 162 milions of miles nearer the earth than at another. This planet is ſometimes in conjunction with the ſun, at other times in oppoſition; but Mercury and Venus are never in oppoſition to the ſun; yet they have two conjunctions, inferior and ſuperior.

The next to Mars is the planet Jupiter, diſtant from the ſun 424 milions of miles, this planet revolves round the ſun in 4332 days and a half; and is thought to turn on his axis once in 10 hours, ſo that the inhabitants of this planet have ſhort days, and long years, this planet is ſometimes in conjunction with the ſun, and ſometimes in oppoſition to it; and has four moons or attendants moving round him, at different diſtances in different periods, but as they are not viſible to the naked eye; we ſhall not at this time ſay much about them, but proceed to the next and fartheſt in our ſyſtem *(viz)* Saturn, diſtant from the ſun 777 milions of miles, revolving round it, at the ſlow and tardy rate of once, in the ſpace of 10759 days and one third; this planet alſo has five moons or attendants, called ſatellites moving round him, at different diſtances in different periods, but they are all inviſible to the unaſſiſted eye. This planet has a vaſt ſurprizing ring; that appears through a good glaſs, to be ſuſpended round his body of a conſiderable depth; but of what uſe it may be, is all conjecture.

Aſtronomers have diſcovered, that, the real orbits of all theſe planets not excepting the earth, are eliptical the ſun in the focus of each orbit; conſequently they are all at times nearer to that fountain of light, and at times farther removed; and this introduces an irregularity in their motions in their orbits, being accelerated in motion when neareſt the ſun, in their perihelion; and a little retarded when at their fartheſt diſtance from the ſun in aphelion; but their apparent motions, as viewed from the earth alſo in motion, is much more irregular among the fixed ſtars, their geocentric motions being ſometimes progreſſive, according to the order of the ſigns, at other times retrograde, at other times ſtationary, or without any apparent motion; all which phenomena are curiouſly repreſented in that noble and truly grand piece of machinery called an ORRERY, together with the TELLURIAN and LUNARIUM; to which I recommend the young ſtudent, that would know more of the diſpoſition, motion, and affections of the ſeveral bodies, that compoſe the ſolar ſyſtem.

We ſhall conclude this introduction with a few paradoxes, and their ſolutions, which depend on a through knowledge of the true figure and magnitude of the earth.

Par. 1ſt. There is a certain place upon the earth, where the winds frequently veer round the compaſs, yet always blow from the north.

Sol. This is at the ſouth pole, where there is no ſuch thing as eaſt or weſt, nor ſtrictly any intermediate point, as all the meridians unite there.

Par. 2d. There are two remarkable places on the globe, in each of which, there is but one day and one night throughout the year.

Sol. The two places are the two poles; for there the ſun riſes but once, and ſets once in a year to either, conſequently makes but one day and one night.

Par. 3d. There are two places that lie due eaſt and weſt, diſtant aſunder 600 leagues, and the true courſe and neareſt diſtance, is to ſail 300 leagues due north, and 300 more due ſouth,

Sol. The two places muſt be in the latitude of 75 degrees north, and their difference of longitude 180 degrees, for in this caſe, it is evident, that the true courſe and neareſt diſtance, is from the firſt place to the pole due north, diſtance 300 leagues; and then due ſouth 300 more, which is 300 leagues leſs than ſailing due eaſt or weſt.

Par. 4th. The paralell diſtance, of two places in a conſiderable north or ſouth latitude, is not their neareſt diſtance, nor is it the moſt advantageous courſe, to ſail from one to the other, due eaſt or weſt.

Sol. The neareſt diſtance is on the arch of a great circle, but the parallel diſtance, is an arch of a leſs circle.

Par. 5th. If the ſhip A, ſails round the globe eaſtward about, and the ſhip B, ſails round weſtward about, the men on board the two ſhips, will differ in their account of time among themſelves, and both will differ from thoſe who reſided at the port ſailed from.

Sol. The ſhip A ſailing eaſtward, will gain one day, and the ſhip B ſailing weſtward will loſe one day; conſequently the people on board A will reckon one more, and thoſe on board B one day leſs, than thoſe who reſided at the port.

FINIS.

THE

NAVIGATOR's

VENI-MECUM.

ARITHMETIC.

ALL the operations in Arithmetic are performed by four general rules, viz. Addition, which finds a ſum; Subtraction, a difference; Multiplication, a product; Diviſion, a quotient. Now each of theſe rules hath its proper mark, ſign, or ſimbol, which ought firſt to be well underſtood, both for elegance and expedition in buſineſs.

This mark + is called plus or more, and is the ſign of Addition, as 8 + 12 make 20, again 7 + 9 + 12 make 28.

This mark — is called minus or leſs, and is the ſign of Subtraction, as 12 — 7 is 5.

This mark × is called multiplied, and is the ſign of Multiplication, as 15 × 6 makes 90 the product, alſo, 7 × 3 × 5 is 105.

This mark ÷ is called in reading it between two numbers, divided; and is the ſign of Diviſion, as 60 ÷ 12 makes 5 the quotient. But Diviſion is often thus expreſſed $\frac{72}{8}$ is 9, read 72 divided by 8 is 9 in the quotient.

Other marks and abbreviations in this work are the following

This mark = called equal to, is the ſign of equality, as

$8 + 11 = 19$, alſo $19 - 11 = 8$. And $8 \times 9 = 72$, alſo $72 \div 8 = 9$. As $4 : 12 :: 6 : 18$, is called a proportion, and is read as 4 is to 12 ſo is 6 to 18. for $12 \times 6 \div 4 = 18$.

This mark	Stands for
$\angle$	Angle
R.	Radius
S.	Sine
S. $\angle$	Sine of the Angle.
Tan.	Tangent
Tan. $\angle$	Tangent of the Angle
Com.	Compliment
Diff.	Difference
$\surd$	Square Root
B C$_2$	B C Squared
Lat.	Latitude
Log.	Logarithm.

With ſome others which are obvious, or afterwards explained.

Addition in Arithmetic, is the firſt of the four fundamental rules in that ſcience, and teaches how to find the ſum of two or more numbers.

Addition of ſingle numbers, of thoſe conſiſting of one digit only, is very eaſy; as for example, $4 + 5 + 8 + 7 = 24$.

In compound numbers, Addition is performed by writing down the propoſed numbers in vertical columns, placing units under units, tens under tens, hundreds under hundreds; &c. as in the following examples;

To	2684	721	84	7683
Add	7218	48	27	218
	4729	76	35	94
	3218	9	64	7
Sum	17849			

Rule. Begin by adding all the units firſt, ſetting down the units figure in the ſum, under units, carrying the number of tens to the tens, or next line; thus in the firſt queſtion, $8 + 9 + 8 + 4 = 29$, therefore put the 9 under the units, and for the twenty carry two; then two carried + 1 + 2 + 1 + 8 = 14, ſet 4 under tens and carry 1 to the next line.

Again, 1 carried + 2 + 7 + 2 + 6 = 18, then ſet 8 under hundreds, and carry 1 to the next line.

Again, 1 carried + 3 + 4 + 7 + 2 = 17 which being the laſt line, muſt all be put down as in the example; whence the ſum is 17849.

Subtraction, is the ſecond principal rule, and teaches how to find the difference of any two numbers, by taking the leſs from the greater.

In numbers conſiſting of one or two digits, it is very eaſy, as 12 — 7 = 5 the diff. of 12 and 7.

Alſo, 8 — 3 = 5. and 48 — 36 = 12 &c.

This rule is directly contrary to Addition, but in placing the numbers the ſame caution muſt be uſed as in Addition, to ſet units under units, tens under tens, &c.

Rule, Begin at units figure, and ſubtract the lower figure from that which ſtands over it, ſetting down the difference underneath it, or a cypher, if they chance to be equal; but if the upper figure be leſs than the lower, increaſe the upper figure with ten, and from the ſum ſubtract the lower figure, ſetting down the difference, and carry one to the next lower figure; as in the following example,

From	2853	721	87	12768
Sub.	476	721	87	7683
Diff.	2377			

Here 6 from 3 you cannot, but 6 from 3 + 10 or 13, leaves 7 to ſet down, one carred to 7 makes 8 from 5 + 10 or 15 gives 7 to put down; 1 + 4 is 5 from 8 and 3, 0 from 2 is 2; ſo the difference in the firſt queſtion is 2377.

Multiplication, is the third rule, and teaches how to find the product of any two numbers, as in the following examples.

8 × 4 = 32; 12 × 12 = 144; 25 × 6 = 150

In Multiplication of compound quantities, the firſt factor called multiplicand, is ſet over the other called the multiplier, and the product is ſet under both.

Thus multiply	8472	multiplicand
By	8	multiplier
	67776	product

If the multiplier conſiſts of more figures than one, the whole multiplicand is to be added to itſelf, firſt as often as the units figure of the multiplier ſhews, and as often as the next figure in the multiplier ſhews and ſo on to the end, as in the following example,

multiply	847215
By	842
the particular product of 847215 × 2 =	1694430
D° 847215 × 40 =	3388860
D° 847215 × 800 =	6777720
the total product	713355030

This diſpoſition of the product with reſpect to the right hand figure, follows from the firſt general rule, the right hand figure of each product being always of the ſame local value, with that figure of the multiplier, from whence it is generated.

Again 23000 × 30 = 690000 the product.

Multiplication may be performed by addition only, by tabulating the multiplicand; or by NEIPER's bones, or ſliding rules, or by logarithms.

If you add the logarithm of the multiplicand to the log. of the multiplier, the ſum is the logarithm of the product. Thus,

multiply	144	log	2.15836
By	12		1.07918
product	1728		3.23754

DIVISION is the fourth and laſt principal rule, and teaches to find how often one number is contained in another

other. as 4 is contained 8 times in 32. ∵ 4 is the quotient of 32 divided by 8, 32 being the dividend, 8 the diviſor. And 4 the quotient

Division is juſt the converſe of multiplication and may eaſily and ſafely be performed in large numbers by tabulating the diviſor, alſo as diviſion proves multiplication and the contrary, if you divide the product by the multiplicand, the quotient will come out the ſame as the multiplier, as for example.

```
847215)713355030(842 the quotient
        6777720
        -------
         3558303
         3388860
         -------
          1694430
          1694430
          -------
```

Diviſion may be performed by logarithms.

If you ſubtract the log. of the diviſor from the log. of the dividend, the remainder is the logarithm of the quotient.

Thus,	divide	1728 log.	3.23754
	by	12	1.07918
	quotient	144	2.15836

Addition of ſundry Denominations.

As Pounds, Shillings, Pence, and Farthings, or Yards, Feet, and Inches, or Degrees and Minutes &c.

Rule 1ſt. Place all the terms of the ſame denomination under one another, as pounds under pounds, ſhillings under ſhillings, pence under pence, farthings under farthings, &c.

2d. Begin at farthings, and collect them into one ſum, which divide by 4 (the farthings in a penny) ſet the remainder under farthings, and carry the quotient to the pence row.

3d. Sum up the pence, which divide by 12, ſet the remainder if any under pence, and carry the quotient to ſhillings.

4th. Add up your ſhillings row, divide their ſum by 20, ſet the remainder under ſhillings, and carry the quotient to the pounds, which muſt alſo be caſt up as in addition as in the following example.

	l.	s.	d.
To	274	14	$9\frac{1}{2}$
Add	147	18	$10\frac{3}{4}$
	218	17	$11\frac{1}{4}$
	372	13	$7\frac{3}{4}$
Sum	1014	5	$3\frac{1}{4}$

	deg.	m.	deg.	m.	deg.	m.
To	18	14	64	27	48	34
Add	8	43	14	53	5	14
Sum	26	57				

Subtraction of divers denominations.

Rule 1ſt. Place the terms as directed in addition, the leſs ſum under the greater.

2d. Begin at the loweſt denomination, and take the under number from that above or over it, under which ſet the remainder, but if the under number be greater, ſubtract it from the number of that denomination in the next, and to the remainder add the upper number, which ſet down for the remainder in that place, and carry one to the next denomination, as in the following examples.

	l.	s.	d.	deg.	m.	deg.	m.
From	217	18	$7\frac{1}{4}$	97	11	48	47
Sub.	129	7	$9\frac{1}{2}$	84	21	7	15
Diff.	88	10	$9\frac{3}{4}$	12	50	41	32

Multiplication of Money.

In carrying on buſineſs of buying or ſelling by the yard, pound, hundred weight, foot, &c. at ſo much per yard &c.

Multiply the price per yard, by the number of yards if not above 12; if above 12, multiply by ſuch numbers as will conſtitute the number propoſed, as for 48 yards multiply the price per yard by 6, and that product by 8, becauſe 6×8 = 48, and for 53 multiply the price per yard by 10 and that product by 5 becauſe 5×10=50, to which add the product of the price per yard by 3, and the ſum is the price of 53 yards, as in the following examples.

s. d.
What come 8 yards linen to at 4 7 ½ per yard?
8
£. 1 17 0 0 anſ.

What come 48 yards to at 11 8 ¾ per yard?
6
3 10 4 ½
8
£. 28 3 0 0 anſ.

What come 53 yards to at 14 10 ½ per yard?
10
£. 7 8 9 0
5
37 3 9 0
14s. 10d. ½ × 3 = 2 4 7 ½
£ 39 8 4 ½ anſ.

If the number of yards, &c. be 100, multiply the price per yard by 10, and that product by 10.

What come 100 feet timber to at 2s. 7d. ½ per foot?
10
1 6 3 0×8
10
The price of 100 feet £. 13 2 6 0
carried forward

The price of 100 feet £. 13 2 6 0
If 700 multiply that product by 7

The price of 700 feet = 91 17 6 0
If 780 multiply the 10 line by 8 = 10 10 0 0
If 789 multiply the price per foot by 9 = 1 3 7 $\frac{1}{2}$

Anſ for 789 feet = £ 103 11 1 $\frac{1}{2}$

If the price of a ſtone be required, from the price of a pound given, multiply the price per pound by 7, and that product by 2, becauſe 7 × 2 = 14lb. = 1 Stone.

What come 11 ſtones of Beef to at 4d. $\frac{1}{4}$ per lb.?

7

Sh. 2 5 $\frac{3}{4}$
2

Per ſtone 4 11 $\frac{1}{2}$
11

£. 2 14 6 $\frac{1}{2}$ Anſwer.

If the price of a hundred weight be required, from the price per lb.; multiply the price per lb. by 7, and the product by 4 for the price of a quarter; and the price of a quarter multiplied by 4, gives the price of one hundred weight.

What come 9 Cwt. 3 Qr. 21 lb. to, at 5d $\frac{1}{4}$ per lb.

7

3 0 $\frac{3}{4}$ × 3
4

Per Quarter 12 3 0 × 3
4

Per Hundred £ 2 9 0 0
9

		£	s	d	
Eleven Hundred	comes to	22	1	0	0
Three Quarters		1	16	9	0
Twenty-one lb.			9	2	$\frac{1}{4}$

Anſwer £ 24 6 11 $\frac{1}{4}$

MULTIPLICATION of Feet and Inches.

This rule is applicable to the meaſuring bales, boxes, caſes and other packages, for freight, cartage, ſtorage, &c.

If the feet in the multiplier be 12 or under, multiply by the feet, and then by the inches, or for the inches take the aliquot parts as in the following example.

If a package be 9 feet 8 inches long, 4 feet 5 inches broad, 3 feet 9 inches deep, required the ſolid feet?

	F.	In.		
Breadth	4	5		
Depth	3	9		
Product by three feet	13	3		
Do. by nine inches	3	3	9	
	16	6	9	
	9	8		
Product by nine feet	149	0	9	
Six inches is one half	8	3	4	6
Two inches is one third of ſix	2	9	1	6
Content	160	1	3	0

Which at 50 feet to the tun is 3 tuns 10 feet.

REDUCTION is the changing coin, weight, or meaſure, from one denomination to another, and is either deſcending by multiplication, as pounds multiplied by 20, produces ſhillings; or aſcending by diviſion, as ſhillings divided by 20 quotes pounds.

Reduce 43l. 18s. 9d. $\frac{1}{4}$ to farthings?

Iſt. $\overline{43 \times 20} + 18 = 878$ Shillings.

IId. $878 \times 12 + 9 = 10545$ Pence.

IIId. $10545 \times 4 + 1 = 42181$ farthings. Anſwer.

Reduce 42181 farthings to pence, ſhillings and pounds.

Iſt. $42181 \div 4 = 10545$ pence and $\frac{1}{4}$

II. $10545 \div 12 = 878$ ſhillings and 9 pence.

III. $878 \div 20 =$ 43l. 18s. 9d. $\frac{1}{4}$ Anſwer.

The Single RULE of THREE Direct.

This Rule finds a fourth proportional, having three terms given, by ranging or ſtating in order, ſo that the firſt and third terms be of one name, then divide the product of the ſecond and third by the firſt for the anſwer.

If 12 yards of cloth coſt 45s. what coſt 164 yards at that rate?

yds. s. yds. s.
Sol. As 12 : 45 : : 164 : 615.
3 41 41
45
180
3 | 1845
£ s.
615 = 30 15 Anſwer.

If 3 buſ. 3 pecks of Wheat, coſt 2l. 17s. 9d. what ſhall be paid for 11 qr. 5 buſ. 2 pecks at that rate? and what coſt 1 buſ. thereof? B. P. pecks

By reduction 3 3 = 15
11 Q. 5 2 = 374
£. 2 17 9 = 693d.
P. d. P. d.
As 15 : 693 : : 374 : 17278 $\frac{3}{4}$ = 71l. 19s. 10 $\frac{3}{4}$
5)231 46 $\frac{1}{5}$ Anſwer.
46 $\frac{1}{5}$ 17278

For the price of one Buſhel.
P.. d. P. d. s. d.
As 15 : 693 : : 4 : 184 $\frac{4}{5}$ = 15 4 $\frac{3}{4}$ Anſwer.
5 : 231
4
5) 924
184 $\frac{4}{5}$

DECIMAL FRACTIONS

This is an artificial method of repreſenting quantities of any kind, as coin, weight, meaſure, &c. in tenths, hundreds,

dreds, thouſands, &c. ſeparated from integers by a dot, as 4l. 10s. = 4.5l.; that is 4 pounds and 5 tenths. Coin, Weight, or meaſure, are reduced to decimals by ſhort diviſion, thus,

Reduce 17s. 9d. $\frac{3}{4}$ to the Decimal of one pound?

$$\begin{array}{r|l} 4 & 3.00 \\ 12 & 9.75 \\ 20 & 17.8125 \end{array}$$

$\because$ 17s. 9d. $\frac{3}{4}$ = .890625 £.

Tun. Cw. Qr. lb. Oz.
Reeduce 3 14 2 21 8 To the decimal of one tun?

$$\begin{array}{r|r|l} & 16 & 8.0 \\ 28 & 7 & 21.5000 \\ & 4 & 3.07142857 \\ & 4 & 2.76785714 \\ & 2|0 & 14.69196428 \end{array}$$

Tun. C. Qr. lb. oz.
$\because$ 3 14 2 21 8 = 3.734598214 Tuns.

Reduce 5l. 2m. 7 fur. 34 poles to the decimal of a degree?

$$\begin{array}{r|l} 40 & 34.00 \\ 8 & 7.8500 \\ 3 & 2.98125 \\ 20 & 5.99375 \end{array}$$

l. m. fur. p.
$\because$ 5 2 7 34 = .2996875 degrees.

A vulgar fraction is put into decimals, by dividing the numerator by the denominator.

Thus $\frac{1}{4} = .25$, $\frac{1}{2} = .5$, $\frac{3}{4} = .75$.

Compound fractions thus,

$$\frac{\overset{}{1}}{\underset{1}{\cancel{2}}} \text{ of } \frac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{3}}} \text{ of } \frac{\overset{1}{\cancel{3}}}{4} = \frac{1}{4} = .25$$

$\frac{3}{5}$ of $\frac{4}{9} = \frac{12}{45} = \frac{4}{15} = .26$ anſ.

The value of a decimal is found, by multiplying it by the known parts of the integer, thus,

£.	.890625
	20
Shill.	17.812500
	12
Pence	9.7500
	4
	3.00

∵ .890625l. = 17s. 9d. $\frac{3}{4}$ anſ.

Decimals are added and ſubtracted as whole numbers, placing tenth parts under tenth parts, hundreds under hundreds, &c. as under.

To	68.472		
Add	4.76	From	21.804
	.2847	Sub.	7.1498
	.098		
		Diff.	14.6542
Sum	73.6147		

Decimals are multiplied as whole numbers, only ſeparating as many figures in the product for decimals, as there are decimals in both factors.

Multiply	84.72	.058421
By	.543	.0631
	25416	58421
	33888	175263
	42360	350526
Product	46.00296	.0036863651

To

To meaſure a package by Decimals.

F. I. F.

If the length be 9 8 = 9.6 }
Breadth 4 5 = 4.416 } in decimals
Depth 3 9 = 3.75 }

22083

309166

13250

165.6250

9.6

9|9937500

11041666

14906250

F. I. P.

160 1 3 = 160.104166 anſ.

Decimals are divided as whole numbers, only continue the diviſion until the decimal places in the dividend, exceed thoſe in the diviſor, and ſeperate that exceſs for decimals in the quotient.

$$\frac{48.376}{9.2417} = 5.234 \text{ the quotient}$$

The RULE of THREE in Decimals.

If one ſtone of beef coſt 3s. 9d. what is the value of 9 cwt. 2qr. 21lb ? and what is it a pound ?

By reduction 1ſto. = $\frac{1}{8}$ cwt. = .125 cwt.

9cwt. 2qr. 21lb. = 9.6875 cwt. 3s. 9d. = .1875l.

As .125cwt. : .1875l. :: 9.6875cwt. : 14.53125l.
dividing the 1ſt. and 2d. terms by 5 give.
As .025 : .0375 :: 9.6875 ÷ 5 again
As .005 : .0075 :: 9.6875 ÷ 5 again
As .001 : .0015 :: 9.6875 : 14.53125

.0015

484375

96875

.001).01453125(14.53125
or 14l. 10s. 7d. $\frac{1}{2}$ anſwer

or thus as .125 cwt. : .1875l. :: 9.6875 cwt. :
8 8 1ſt. and 2d. × 8.

give 1.000 1.5000 again 1ſt. and 2d. × 2.
2 2

As 2 : 3 :: 9.6875 : 14.53125
3

2|29.0625

14l. 10s. 7d. $\frac{1}{2}$ = 14.53125 anſwer

For the price of one pound.

14|7|.1875
|2|.0267857
d.
| |.0133928 = 3.21428 per lb.

To extract the ſquare root, is to find from a given number, ſuch a number as multiplied into itſelf or ſquared may produce the propoſed number or power.

As the ſquare root of 144 is 12, becauſe 12 × 12 = 144.
Required the ſquare root of 8472184?

8472184 (2910.7 the root
4

49)447
441

581)621
581

58207)408400
407449

951

Every new diviſor is made by doubling the root, and annexing the next figure in the root in the units place thereof as 2 × 2 = 4 and 9 put to it makes 49 the firſt diviſor.

Alſo 29 × 2 = 58 and 1 put to it makes 581 the ſecond diviſor &c.

If the two legs of a right angled triangle, viz. the baſe and perpendicular be given; the hypothenuſe is equal to the ſquare root of the ſum of their ſquares?

If a ſhip ſails from a port due north thirty-ſix miles, and another due eaſt forty-eight miles, required their diſtance aſunder?

Thus $36 \times 36 = 1296$ and $48 \times 48 = 2304$.
And $\sqrt{1296 + 2304} = 60$ Miles Anſwer.

If the hypothenuſe and one leg be given; the ſquare root of the difference of their ſquares is the other leg.

If a ſhip ſails 60 miles into the N. E. quarter, and is 36 miles farther north, required how much ſhe is to the eaſtward?

$60 \times 60 = 3600$ and $36 \times 36 = 1296$.
Then $\sqrt{3600 - 1296} = 48$ Miles to the Eaſtward.

If the higheſt mountain on the terraqueous globe be three miles high; how far can it be ſeen on plain ground or at ſea?

Sol. If we allow the earth's diameter 8000 miles.

Then
$$\begin{array}{rcl} 4003 \times 4003 & = & 16024009 \\ 4000 \times 4000 & = & 16000000 \\ \hline & & 24009 \end{array}$$

$\sqrt{24009} = 154.9$ Miles nearly. Anſwer.

If the diameter of Jupiter be 20-times bigger than the earth's diameter; how far may a jovian mountain, three miles high, be ſeen on his ſurface?

$$\begin{array}{l} 4000 \times 20 = 80000,\ 80000 + 3 = 80003 \\ 80003 \times 80003 = 6400480009 \\ 80000 \times 80000 = 6400000000 \\ \hline \end{array}$$

$\sqrt{480009} = 692.8$ miles. Anſwer.

If the moon's diameter be $\frac{1}{4}$ of the earth's diameter, how far may a lunar mountain three miles high, be ſeen on the ſurface thereof?

$\sqrt{1003 \times 1003 - 1000 \times 1000} = 77.5$ miles Anſ.

The lengths of pendulums are inverſely as the ſquares of their vibrations in the ſame time.

If a pendulum 39.2 inches long, vibrate 60 times in a minute, what length muſt a pendulum be to vibrate 30 times in a minute?

As $\overline{60 \times 60} : 39.2 :: \overline{30 \times 30} : 157.2.$

3600

235200
1176

9|00)1411|20.0
156.8 = 13.06 feet. Anſwer

The magnitudes of all ſimilar plain figures are in the duplicate ratio of their dimenſions.

If the ſide of an Orchard be 100 yards, required the ſide of another nine times as big, and of another half as great?

$$\left.\begin{array}{l}\sqrt{100 \times 100 \times 9} = 300 \text{ yards.}\\ \sqrt{\dfrac{100 \times 100}{2}} = 70.71 \text{ yards.}\end{array}\right\} \text{Anſwer.}$$

If the diameter of a circular fiſh pond be 24 yards, required how much that diameter muſt be lengthened, at each end equally to be five times as great in the area?

$\sqrt{24 \times 24 \times 5} = 53.6$
24

$\frac{1}{2}$|29.6

Anſwer 14.8 yards at each end.

If 12 inches length of an iron bar, that is one inch the ſide of its ſquare weigh two pounds, what will a bar of the ſame length weigh, the ſide of its ſquare one quarter of an inch?

As $\overline{1 \times 1} ; 2 :: \overline{25 \times .25} : .125$ lb. or 2 ounces.

If 30 bars of iron, each 7 inches about, be a cart load; how many bars each the ſame length of the former, will be a cart load that are five inches about?

As $7 \times 7 : 30 :: 5 \times 5 : 58.8$ anſwer
49

25)1470(58.8

The

The ſquare root by logarithms.

Half the log. of any number is the log. of the ſquare roo of that number.

As $\sqrt{256}$ its log. is — 2.40824 one half thereof
is the log. of 16, 1.20412 the root required.

The log. of any number multiplied by 2 gives the log. of the ſquare of that number.

As the log. of 25 is 1.3979
2
is the log. of 25 × 25 = 625 2.7958

Alſo one third of the log. of any number is the log. of the cube root of that number.

Required the cube root of 1728? Log. 3.23754
One third of which is 1.07918
The Log of 12.
The cube root of 1728, for 12 × 12 × 12 = 1728.

To find a mean proportional by logarithms.

Half the ſum of the log. of any two numbers, is the log. of the mean.

Required a mean proportional between 12 and 192?
To log. of 12 = 1.07918
Add log. of 192 = 2.28330
2|3.36248
the log. of 48 1.68124
for as 12 : 48 :: 48 : 192 Proof

To find a third proportional by logarithms.

From twice the log. of the greater number ſubtract the log. of the leſs, and the remainder is the log. of the third proportional.

Required a third proportional to 12 and 48?
The log of 48 is 1.68124
multiplied 2
3.36248
Subtract log. of 12 = 1.07918
Log of 192 2.28330

for as 12 : 48 :: 48 : 192 proof.

To find a 4th. proportional by logarithms.

To the comp. arithmetic of the log. of the firſt number add the logarithms of the other two numbers, and the ſum is the log. of the fourth proportional.

Required a 4th. proportional to 12.48. and 192?

Log. of 12 is	1.07918
its comp. arithmetic is	8.92082
Log. of 48 is	1.68124
Do. 192 is	2.28330
Log. of 768	2.88536

12 : 48 :: 192 : 768.

The compliment arithmetic of a log. is what it wants of the radius of your tables, or it is the reſidue of every figure to 9 beginning at the left hand, and of the laſt to 10.

The Rule of Three Direct by Logarithms

Having ſtated and reduced the terms, add the log. of the ſecond and third terms together, and ſubtract the log of the firſt, the remainder is the log of the 4th. or anſwer.

If 7 yards and $\frac{1}{2}$ of cloth coſt 1l. 15s. what coſt 127 yards at that rate?

Per reduction $7\frac{1}{2} = 7.5$ 1l. 15s. = and 1.75.

∵ As 7.5 yards log.	0.87506
: 1.75l.	0.24304
:: 127 yards	2.10380
	2.34684
: 29.63l.	1.47178

or 29l. 12s. 7d. anſwer

Again as 7.5 : 1.75 :: 127 : 29.63 = 29l. 12s. 7d. proof.

The RULE of THREE INVERSE by Logarithms.

State as before directed, and from the ſum of the log. of the firſt and ſecond terms, ſubtract the log. of the third term, and you have the log. of the fourth term or anſwer.

If I lend my friend 500l. for 9 months, how long ought he to lend me 150l. to requite my kindneſs?

As

$$\begin{array}{ll} \text{As 500l. log.} & 2.69897 \\ :\ 9 \text{ months} & 0.95424 \\ ::\ 150\text{l.} & 2.17609 \\ \hline & 3.65321 \\ \hline :\ 30 \text{ mo.} & 1.47712 \end{array}$$

Again as 500 : 9 :: 150 : 30 mo. anſ. proof

The Double Rule of Three by Logarithms.

Theſe queſtions may be done by two ſtatings in the ſingle rule, and worked as ſuch.

If 12 ſtudents ſpend 18l. in 9 months, how much will ſerve 40 ſtudents 16 months?

or you may ſtate thus,

$$\begin{array}{cc} \text{Stu.} & \text{M.} \\ 12 & 9 \\ 40 & 16 \end{array} \quad \text{X} \quad \begin{array}{c} £ \\ 18 \\ * \end{array} \left. \right\} \frac{\overset{10}{\cancel{40}} \times 16 \times \overset{2}{\cancel{18}}}{\underset{3}{\cancel{12}} \times \underset{1}{\cancel{9}}} = \frac{320}{3} = 106.\underset{.}{6}$$

Thus by logarithms,

$$\begin{array}{lrl} \text{To Log.} & 40 & 1.60206 \\ \text{Add} & 16 & 1.20412 \\ \text{Log.} & 18 & 1.25527 \\ \hline & & 4.06145 \\ \hline \text{Log.} & 12 & 1.07918 \\ \text{Do.} & 9 & 0.95424 \\ \hline \end{array} \begin{array}{l} \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} + \\ \\ \left.\begin{array}{l} \\ \end{array}\right\} + \end{array} \Bigg\} -$$

$$\begin{array}{ll} \text{l. s. d.} & 2.03342 \\ 106\ 6\ 8 = 106.6 & 2.02803 \text{ anſwer.} \end{array}$$

The uſe of Gunter's Line, with Compaſſes,

In multiplication by ſcale and compaſſes, extend from one to the multiplicand, and that extent ſet the ſame way, from the multiplier reaches to the product.

For 8 × 6 = 48. and 25 × 6 = 150

Extend from 1 to 8, and that extent ſet on 6 falls on 48 the product, alſo the extent from 1 to 25, reaches from 6 to 150.

The

The uſe of the ſliding Gunter.

Set 1 on the ſlider, to the multiplicand 8 on the rule, then againſt the multiplier 6 on the ſlider, ſtands 48 the product on the rule.

In diviſion by ſcale and compaſſes.

Extend from the diviſor to 1, and that extent ſet from the dividend the ſame way, falls on the quotient.

For 48 ÷ 8 = 6 and 150 ÷ 25 = 6

Extend from 8 to 1 and that extent ſet from 48 falls on 6 the quotient, alſo the extent from 150 to 1, reaches from 25 to 6 the quotient.

By ſliding Rule,

Set the dividend 48 on the ſlider, to the diviſor 8 on the rule, then againſt 1 on the rule ſtands 6 the quotient on the ſlider.

In the rule of three direct, by ſcale and compaſſes.

Extend from the firſt term to the third, and that extent will reach the ſame way, from the ſecond term to the fourth.

If 5 yards coſt 3l. 10s. what coſt 28 yards?

Extend from 5 to 28, and that extent ſet on 3 $\frac{1}{2}$ falls on 19.6 = 19l. 12s.

By ſliding rule, ſet 5 the firſt term on the ſlider, to 28 the third term on the rule, then againſt 3.5 the ſecond term on the ſlider ſtands 19.6. on the rule = 19l. 12s.

Board meaſure by ſcale and compaſſes.

Extend from 12 to the breadth in inches and that extent ſet the ſame way from the length in feet falls on the content.

If a board be 14 inches broad and 27 feet long, required its content?

Extend from 12 to 14, and that extent reaches from 27 to 31 $\frac{1}{2}$ feet the content.

By ſliding rule.

Set the length on the ſlider 27, to 12 on the rule of equal radius, then againſt the breadth 14 on the rule, ſtands 31.5 on the ſlider, the content.

By the pen 27 × 14 ÷ 12 = 31.5 proof.

To meaſure round or rough ſquared Timber.

In practice according to cuſtom, meaſure the length of the piece in feet, then gird it in the middle with a line, which double and meaſure on a line of inches, then half that meaſure call a fourth of the girth or ſide of the ſquare.

By Scale and Compaſſes.

Extend from 12 to the fourth of the girth, which extent turned twice on the ſame way from the length, falls on the content or ſolidity of the piece in feet.

If a piece of timber be 37 feet long, and a fourth of the girth be 16 inches, required its content?

Extend from 12 to 16, and that extent turned twice on from 37 falls on 65.5 or 65 and $\frac{1}{2}$ feet the content.

By ſliding Rule.

Set the length 37 on the ſlider, to 12 on the girth line, then againſt 16 the fourth of the girt on the rule or girt line, ſtands 65.5 on the ſlider the anſwer.

By the pen $\frac{16 \times 16 \times 37}{144} = 65.7$ anſwer

or $37 \times 1.7 = 65.7$ feet anſwer

To meaſure unequal ſquared Timber, by Scale and Compaſſes.

Extend from 12 to the breadth in inches, which ſet from the depth in inches, and then extend from where the other foot falls to 12, that laſt extent ſet on the length in feet falls on the content.

If a piece of timber be 20 inches broad, 14 deep, and 18 feet long, query its ſolid content?

Extend from 12 to 20, that extent ſet the ſame way from 14 falls near 23.4 then the extent from that point to 12, ſet on the length 18 falls on 35 feet the ſolid content required.

By ſliding Rule.

Set the breadth 20 on the ſlider to 12 on the equal radius of the rule, then againſt the depth 14 on the rule, ſtands a point on the ſlider near 23.4, which ſet to 12 on the rule, then againſt 18 on the rule, ſtands 35 on the ſlider the anſwer.

By the pen $\frac{20 \times 14 \times 18}{144} = 35$ feet.

To cut from a board of a given breadth an aſſigned number of feet, by ſcale and compaſſes.

Extend from the propoſed number of feet to the breadth in inches, and that extent ſet from 12 the contrary way falls on the length.

What length of a plank that is 15 inches broad will make 18 feet flat meaſure?

The extent from 18 to 15 ſet from 12 the contrary way gives 14.4 feet the anſwer.

By ſliding Rule,

Set the propoſed number of feet on the ſlider to the breadth 15 inches on the equal radius on the rule, then againſt 12 on the rule ſtands 14.4 on the ſlider the anſwer.

By the pen. $\frac{18 \times 12}{15} = 14.4$ feet anſwer.

To cut from a piece of equal ſquared timber, an aſſigned number of feet. By ſcale and compaſſes.

Extend from 12 to the ſide of the ſquare, and that extent turned twice on the contrary way, from the propoſed number of feet falls on the length required.

If a piece of timber be 16 inches ſquare what length thereof will make 25 ſolid feet?

Extend from 12 to 16, and that extent turned twice on from 25, the contrary way falls on 14 feet the anſwer nearly.

By ſliding Rule.

Set the propoſed number of feet 25, on the ſlider to the ſide of the ſquare 16 on the girt line, then againſt 12 on the girt line, ſtands 14 feet on the ſlider the anſwer nearly.

By the pen $\frac{25 \times 144}{16 \times 16} = 14$ nearly Proof.

By contraction $1.5625 \times 9 = 14.0625$ Anſwer.

To Gauge a Caſk by ſcale and compaſſes.

The Gauge point for ale or beer meaſure is $18.95 = \sqrt{\frac{282}{.7854}}$ and the wine gage point is $\sqrt{\frac{231}{.7854}} = 17.15$.

Therefore extend from 1 to .7 and that extent ſet the ſame way from the difference of the bung and head diameters, falls on a number, to which add the head diameter and the ſum is a mean diameter.

Then extend from the gauge point, to that diameter, and that extent turned twice on the ſame way from the length, falls on the content ale or wine, according to the gauge point uſed.

Admit the length of a caſk 43 inches, diameter at bung 28, head Dto. 20 inches, Query its content ale and wine gallons?

Extend from 1 to .7 and that extent ſet from 28 — 20 = 8 falls on 5.6 to which add 20 makes 25.6 the mean diameter, then, extend from 18.95 to 25.6, and that extent, turned twice on from 40 falls on 73 ale gallons. Alſo the extent from 17.15 to 25.6 turned twice on from 40 falls on 89.7 wine gallons.

By ſliding Rule.

Firſt, $28 - 20 = 8$ and $8 \times .7 = 5.6$ then $20 + 5.6 = 25.6$ the mean diameter. Then,

Set the length of the caſk 40 on the ſlider, to the gauge point 18.95 on the girt line, then againſt the mean diameter 25.6 on the girt line, ſtands 73 ale gallons on the ſlider.

By the pen $\frac{25.6 \times 25.6 \times 40}{359} = 73$ gallons anſwer

For wine ſet 40 on the ſlider, to the gauge point for wine 17.15 on the girt line, then againſt the mean diameter 25.6 on the girt line, ſtands 89.7 gallons anſwer.

By the pen $\frac{25.6 \times 25.6 \times 40}{294} = 89.7$ gallons anſ.

The length of a ſhip's keel, and breadth at the beam given, to find her tunage.

By Scale and Compaſſes,

Extend from $\sqrt{94 \times 2} = 13.71$ to the breadth of the beam, and that extent turned over twice the ſame way from the length of the keel, falls on the anſwer.

If a ſhip's keel be 84 feet and the breadth at the beam 25 feet, required the tunage of that ſhip?

Extend from 13.71 to the bread that the beam 25, and that extent turned twice over from the length of the keel 84, falls at laſt on 279 2 the tunage required.

By the pen $\frac{25 \times 12.5 \times 84}{94} = 279.2$ proof

By ſliding Rule,

Set the length of the keel 84 on the ſlider, to 13.71 on the girt line, then againſt the breadth at the beam on the girt line 25, ſtands 279.2 tuns on the ſlider the anſwer.

The conſtruction of the plain Scale. Pl. I. Fig. 1.

The plain ſcale is an inſtrument of great utility in navigation, &c. for ſolving the caſes of plain, traverſe, parallel, mercator's, and middle latitude ſailing, &c.

1ſt. with any radius as CE deſcribe the ſemicircle CBD, at E and C raiſe two perpendiculars. as EF and CG, divide the arch CB into 9 equal parts; from the centre E, through the ſeveral diviſions, draw lines to cut the perpendicular, CG, which thereby becomes a line of tangents.

2d. For the ſemi-tangents, or half tangents, let lines be drawn from the point D, through theſame diviſions upon the arch CB, and they will divide the radius BE into a line of ſemi-tangents. Per Eu. 3 and 20th.

3d. For the ſecants, transfer the lines drawn from the center through the ſeveral diviſions of the quadrant CB, to form the line of tangents, to the line EB produced to F, ſo ſhall the line EF become a line of ſecants.

4th. For the ſines, from the ſeveral diviſions of the quadrant CB, let fall perpendicularsupon the radius CE, which will thereby be divided into a line of ſines, to be numbered from E to C.

5th. For the chords, the arch CB being divided into nine equal parts, in the points 10.20.30, &c. if lines be conceived to be drawn from C to each of theſe diviſions, they will be the chords of their reſpective arches, wherefore ſeting one foot of the compaſſes in the point C, and transfering the ſeveral lengths C 10, C 20, C 30, &c. to the line CB, it will thereby be divided into a line of chords.

The ſeveral lines which in the figure are drawn through every tenth degree, might in the ſame manner be conſtructed to every degree, if the arch were large enough to contain 90 diſtinct diviſions in one quadrant.

6th. For a line of rhumbs, divide the arch DB into 8 equal parts in the points 1.2.3.4, &c. then ſetting one foot of the compaſſes in D, transfer the ſeveral diviſions D 1, D 2. D 3. from the arch to the line DB; which by this means is divided into a line of rhumbs, each of which will anſwer to an angle of 11d. 15m.

The conſtruction of Gunter's ſcale called by navigators ſimply the Gunter, which is a large ſcale two feet long, and about an inch and a half broad, with artifical lines delineated on it, of great utility in ſolving queſtions in Trigonometry, Navigation, &c.

Gunter's line of numbers, is properly a logarithmic ſcale of proportionals, or logarithms in minature.

Therefore if you make a line of 1000 equal parts, equal to the diſtance on the line of numbers, from 1 to 10, then on the beginning of the line you would graduate, ſet 1, and from 1 ſet the log. of
2 = 301
3 = 477
4 = 602
5 = 699
6 = 778
7 = 845
8 = 903
9 = 954
From the ſcale of equal parts.

And the diſtances will repreſent the numbers 2. 3. 4. 5. 6. &c. on Gunter's line of numbers, as per *Fig*. 2. Plate I.

To conſtruct the Line of Logarithmic ſines on Gunter's ſcale. *Fig*. 2.

From the ſcale of equal parts, take the numbers expreſſing the arithmetical compliments of the log. ſines of the ſucceſſive degrees, intended to be put on the ſcale deſcending orderly from 90 deg. theſe diſtances, ſucceſſively laid from the mark repreſenting 90 deg. at the right hand end of the ſcale, will give the ſeveral diviſions of a ſcale of logarithmic ſines.

Or thus as all the degrees from 6 to 90 fall on one radius the log. ſines of

6°	are	.019	radius 1000
10		239	
20		534	
30		699	
40		808	
50		884	
60		937	
70		973	
80		993	

Theſe points tranſfered from the line of equal parts, to

F

the line of ſines as per figure, gives the reſpective diviſions on the line of ſines required; and ſo on for the intermediate diviſions, &c.

To conſtruct the Line of Logarithm, Tangents, on GUNTER's ſcale. *Fig.* 2.

Theſe are laid down in the ſame manner and for the ſame reaſons, that the ſines were, the tangent 45 deg. ſtanding againſt ſine 90 deg.

The diviſions for tangents above 45 deg. are reckoned on the ſame line from 45 deg. towards the left-hand, or any tangent, and its co. tangent are expreſſed by the ſame diviſion.

Thus one mark ſerves for 40 and 50 degrees and the diviſion at 30 ſerves for 60 deg. that at 20 for 70 deg. and ſo for all the reſt of the intermediate diviſions.

To conſtruct the Line of Logarithmic verſed ſines on GUNTER's ſcale. *Fig.* 2.

From the line of logarithmic ſines, take the diſtance between 90 deg. and any ſine; that diſtance, being twice repeated from the termination of the line of verſed ſines, againſt 90 deg. will give the diviſion for twice the compliment of that ſine or arch.

Thus extent from ſine 90 to ſine 70, twice turned on the verſed ſine gives the diviſion of $40 = 20 \times 2$ that is twice the compliment of 70, alſo the extent from 90 to 40 on the ſines gives the mark or diviſion on the verſed ſines correſponding to the compliment of $40 = 50 \times 2 = 100$ and ſo of others.

To draw a Line through a given Point m, Parallel to a given Line A B. *Fig.* 3.

With any ſuitable radius, ſet one foot of the compaſſes on the point m, ſtrike the arch $x\,z$ to cut A B in x, then with one foot on x ſtrike the arch $m\,n$ to cut A B in n, make with your compaſſes $x\,z = m\,n$, then a line drawn through $m\,z$, will be parallel to A B. *W. W. R.*

To raiſe a Perpendicular at a point A, taken any where in a Line B C. *Fig.* 4.

With a convenient radius, and one foot of the compaſſes on A, ſtrike *x*, *z*, *n*, make $xz = zn = xA$, and with the ſame radius and one foot on *z* ſtrike the arch *a*, alſo on *n* with the ſame radius ſtrike the arch *b* to interſect the arch *a* in *d*, draw the line A *d*, and it ſhall be perpendicular to the line B C at the point A. *W. W. R.*

To let fall a Perpendicular from a given point *d*, to a right Line BC. *Fig.* 5.

Draw a line from the given point *d*, to the line B C as *x d*, on the middle thereof, as at *z* ſtrike the arch *x* A, to cut B C in A, draw *d* A, and it is perpendicular to B C. *W. W. R.*

To Project, or Meaſure any right lined Angle. *Fig.* 6.

Firſt draw a line, then with a ſweep of 60 from your ſcale of chords, ſet one foot on the angular point A, and ſtrike the arch *m n*, on which arch ſet the chord of the propoſed angle from *m* to *n*, then through A and *n*, draw a line, and the angle is made. If the angle to be projected be obtuſe, take the chord of half thereof, and turn it twice on the arch *m n*.

To Meaſure an Angle, as the Angle B A C. *Fig.* 6.

At the angular point with a radius of 60 deg. from your ſcale of chords ſtrike the arch *m n*, then take *m n* in your compaſſes, which apply to your ſcale of chords, and you have the meaſure of the angle required, if it be acute or under 90°.

If more than 90 or obtuſe, ſet 90 firſt on the arch, and take the remainder, which apply to your chords, and add that remainder to 90 for the meaſure of the angle required.

TRIGONOMETRY.

TRIGONOMETRY, is a word derived from the Greek, and implies the meaſures, relations, affections, properties, and proportions; among the ſides and angles of all ſimilar plain triangles.

I. Every triangle has ſix parts, viz. three ſides and three angles.

II. Any three parts being given (except the three angles) the other three may be found.

III. In all right angled triangles, if the hypothenuſe be made the radius of a circle, the other two ſides or legs, are the ſines of the oppoſite angles.

IV. But if one leg be made the radius of a circle, the the hypothenuſe is the ſecant, and the other leg is tangent of the angle at the centre.

V. In all right angled, right lined triangles, the ſum of the two acute angles is 90 degrees, and all the three angles in one ſum are 180 degrees, therefore if one acute angle be ſubtracted from 90 degrees, the remainder is the other angle.

In the Inveſtigation of Proportions obſerve.

I. To find a ſide, begin with an angle, but to find an angle begin with a ſide.

II. As the ſine of any angle : the oppoſite ſide : : the ſine of any other angle : its oppoſite ſide.

III. As any ſide : the ſine of its oppoſite angle : : another ſide : the ſine of its oppoſite angle.

IV. As one leg : tangent of radius 45 degrees : : the other leg : tangent of its oppoſite angle.

V. In the right angled triangle *A B C*, *Pl.* II. *Fig.* 1. let *A B* the baſe, be the longer leg, *A C* the hypothenuſe, and *B C* the perpendicular, or ſhorter leg.

VI. As *A C* + $\frac{1}{2}$ the longer leg : 86 a conſtant number : : ſhorter leg : the leſs ∠ nearly.

VII. If *n*, be put for the degrees in the leſs ∠ then,

$\frac{57\cdot3}{n}+\frac{3\,n}{1000}$: 1 : : *A C* : the leſs leg *B C* nearly.

VIII.

Plate.1

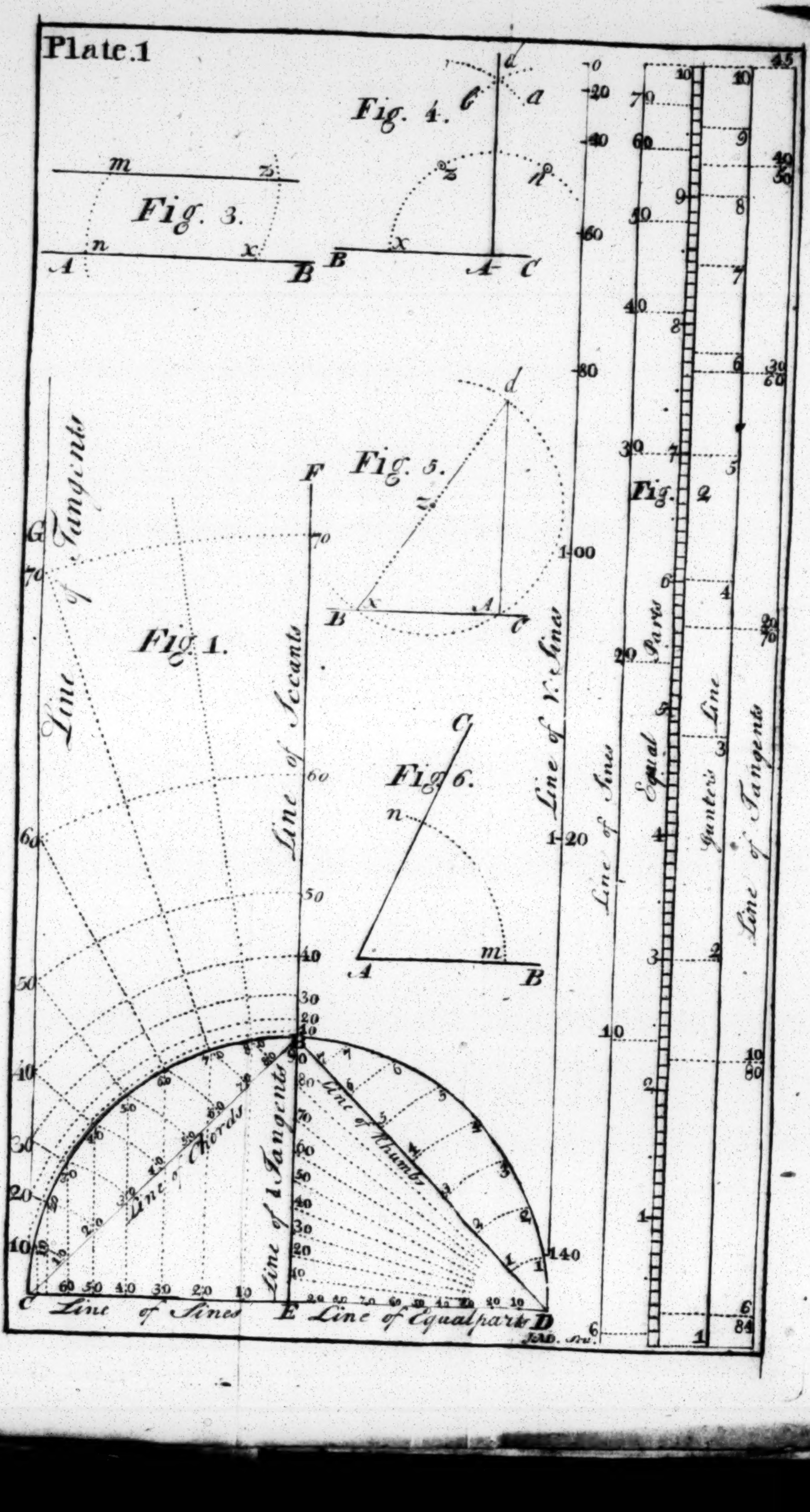


Fig. 4.
d
b
a
z
n
x
B
A
C
Fig. 3.
m
z
n
x
A
B
Fig. 5.
d
z
x
A
B
C
Fig. 6.
C
n
m
A
B
Fig. 1.
Line of Tangents
G
70
60
50
40
30
20
10
Line of Secants
F
Line of Chords
Line of Tangents
Line of Rhumbs
Line of V. Sines
0
20
40
60
80
100
120
140
C
Line of Sines
E
Line of Equalparts
D
Fig. 2
Line of Sines
Equal Parts
Gunter's Line
Line of Tangents
45
10
9
8
7
6
5
4
3
2
1
84
JAD. Sc.

VIII. As $1 : 1 - \frac{1\frac{1}{2}nn}{10000} :: AC : AB$ the greater leg.

IX. $\sqrt{\overline{AB} \times \overline{AB} + \overline{BC} \times \overline{BC}} = AC.$

X. $\sqrt{\overline{AC} \times \overline{AC} - \overline{AB} \times \overline{AB}} = BC.$

XI. $\sqrt{\overline{AC} \times \overline{AC} - \overline{BC} \times \overline{BC}} = AB.$

XII. $AC + BC : R :: AB.$: Tangent of half the ∠ at C.

A Synopsis *of the Six Caſes of Right angled Triangles.*

Caſes.	*Given.*	*Sought.*	*Anſwer by Proportion.*
Firſt.	AC $\angle A$	AB BC	$R : AC :: S\angle A : BC.$ $R : AC :: S\angle C : AB.$
Second	AB $\angle A$	AC BC	$S\angle C : AB :: R : AC.$ $R : AC :: S\angle A : BC.$
Third	BC $\angle A$	AC AB	$S\angle A : BC :: R : AC.$ $R : AC :: S\angle C : AB.$
Fourth	AC AB	$\angle C$ BC	$AC : R :: AB : S\angle C.$ $R : AC :: S\angle A : BC.$
Fifth	AC BC	$\angle A$ AB	$AC : R :: BC : S\angle A.$ $R : AC :: S\angle C : AB.$
Sixth.	AB BC	$\angle A$ AC	$AB : \text{Tang.}R :: BC : \text{Ta.}\angle A$ $S\angle A : BC :: R : AC$

Example in Caſe 1ſt. of right angled triangles. Given AC, 125 miles, and ∠ at A 37 deg. 40 m. to find baſe AB, and perpendicular BC. Pl. II. *Fig.* 1.

Solution. 1ſt. *Geometrically by the plain Scale.*

1ſt. draw a line AB, at A make an ∠ = 37 40, then draw AC = 125 from a ſcale of equal parts, and from C let fall the perpendicular B C, ſo ſhall A B meaſured on the ſcale the hypothenuſe was taken from be 99 miles, and the perpendicular B C, 76.4 nearly.

2d. *By Logarithms, for the baſe A B.*

As radius	90 00	10
: Hypo. A C	125 m.	2.09691
: : S. ∠ at C	52 20	9.89849
: Baſe A B	99 m.	1.99540

For the Perpendicular B C per Logarithms.

As radius	90 00	10
: Hypo. A C	125 m.	2.09691
: : Sine ∠ at A	37 40	9.78608
: Perpendicular B C	76 4 m.	1.88299

3d. *By natural Sines Arithmetically.*

The natural ſine of 37 deg. 40 m. = .611 and of 52 20 = .7916.

As 1 : 125 : : .7916 : 99 = A B nearly.

For the perpendicular B C.

As 1 : 125 : : .611 : 76.3 = B C.

4th. *Inſtrumentally by* GUNTER's *Scale, on ſines and numbers.*

Extend from ſine 90 deg. to ſine 52 20, and that extent will reach from 125 on the line of numbers to 99 on the ſame, = A B ; and the extent from ſine 90 deg. to ſine 37 40 reaches from 125 to 76.4 = B C.

5th. *By* GUNTER's *Scale on the line of numbers only.*

Extend from 1 to .79 and that extent reaches from 125 to 99 = A B ; again the extent from 1 to .611 reaches from 125 the ſame way to 76.4 = B C.

6th. *By B.* MARTIN's *ſliding Gunter, on ſines and numbers.*

Set ſine 90 on the ſlider, to ſine 52 20 on the rule, then againſt 125 on the ſlider, ſtands 99 = A B on the rule.

Again ſet ſine 90 on the ſlider, to ſine 37 40 on the rule, then againſt 125 on the ſlider, ſtands 76.4 on the rule = B C.

7th. By ſliding Gunter on numbers only.

Set 1 on the ſlider, to the natural ſine of 52 20 = .791 on the rule, then againſt 125 on the ſlider, ſtands 99 = A B on the rule.

Again ſet 1 on the ſlider, to .61 on the rule, then againſt 125 on the ſlider, ſtands 76.4 A B on the rule.

8th. By the Sector with line of lines and ſines.

Take the hypothenuſe A C 125 from the centre of the ſector laterally on the line of lines, open the ſector, and ſet that extent ſectorally to 90 on the ſines, then the ∠ at A 37 40 taken ſectorally in the line of ſines, and ſet from the centre of the line of lines gives 76.4 = B C; alſo as the ſector ſtands take the ∠ at C 52 20 ſectorally on the ſines, and ſet it on the line of lines from the ſector's center latterally gives 99 the baſe A B.

9th. By Arithmetic only. To find the leſs leg B C, Plate II. *Fig.* 1. *Theo. 7th.*

$\frac{57.3}{37.6} = 1.5206, \frac{37.6 \times 3}{1000} = .113$ and

$1.5206 + .113 = 1.6336 \because$ as $1.6336 : 1 :: 125 : 76.4 = $ B C.

To find A B. per Theo. 8th.

As $1 : 1 - \frac{1.5 \times 37.6 \times 37.6}{10000} :: 125 : 98.5 =$ A B nearly.

Or $\sqrt{\overline{125 \times 125} - \overline{76.4 \times 76.4}} = 98.9 =$ A B.

N. B. Caſe 2d. and 3d. may be ſolved after the ſame manner, obſerving the proportions and theorems.

Example in Caſe 4th. Given A C 125m. and A B 99m. to find the angles, and leg B C.

1ſt. Geometrically by the plain ſcale. Plate II. *Fig.* 1.

Draw the line A B = 99 from a ſcale of equal parts, make B C perpendicular thereto, then with 125 in the compaſſes as a radius from the ſame ſcale, and one foot on A ſtrike an arch, to cut the perpendicular in C, draw A C, then meaſure the ∠ at A on the ſcale of chords = 37 40, and B C on the ſcale of equal parts = 76.4 miles.

2d. *By Logarithms for the ∠ at C.*

As hypo. A C	125	2.09691
: Radius or ſine	90 00	10.
: : Baſe A B	99	1.99540
: Sine of ∠ at C	52 20	9.89849
which ſubtract from	90 00	

Remainder 37 40 is the ∠ at A.

To find B C, ſee the proportion in the firſt caſe wrought out.

3d. *By the table of natural ſines for ∠ at C.*

As 125 : 1 : : 99 : .792 = nat. ſine of 52 22 the ∠ at C. Now .791 in the table is 52 15 and .793 per d° is 52 30 ∵ $\frac{1}{2}$ the difference 7 m + 52 15 = 52 22m. ∠ C.

Then 90 00 — 52 22 = 37 38 ∠ at A.

Or $\sqrt{1 - .792 \times .792}$ = .611 nearly the natural. ſine of ∠ at A = 37 38

4th. *Inſtrumentally by* GUNTER's *ſcale on the line of numbers and ſines, for ∠ at C.*

As A C 125 : ſine 90° : : A B 99 : ſine 52 22 ∠ at C. Extend from the firſt term, to the third on the line of numbers, and that extent ſet from the ſecond term on the line of ſines, falls on the anſwer on the ſame line.

5th. *By* GUNTER's *line of numbers only.*

See the proportion in the third, and extend from the firſt term 125. to the third 99, and that extent ſet from 1 at the end of the ſcale falls on .792 the natural ſine of 52° 22 the ∠ at C.

6th. *By* Mr. MARTIN's *ſliding Gunter, for the ∠ at C, ſee the 2d. of this example by Log.*

Set the firſt term there 125 on the ſlider, to the third term 99 on the rule, on the line of numbers, then againſt the 2d. term ſine 90° on the ſlider, ſtands the ſine 52 20 on the rule = the ∠ at C.

7th. *By ſliding* GUNTER, *on the line of numbers only, for the ∠ at C, ſee the 3d. hereof.*

Set the firſt term there 125 on the ſlider, to the third term 99 on the rule, then againſt the ſecond term 1 on the ſlider, ſtands .792 on the rule which is the natural ſine of 52 20 the ∠ at C required.

8th. By the Sector, to find the ∠ at C.

Take the hypothenuſe A C laterally from the line of lines, ſet it ſectorally to ſines 90 by opening the ſector, then take the baſe A B 99 lateraly, and apply it to the ſines ſectorally, and it will give 52° 20 the ∠ at C.

To find the perpendicular B C.

Sector as ſet in the laſt, take the ∠ at A 37 40 ſectorally which apply laterally, gives the perpendicular B C 76.4.

10th. To find B C Arithmetically.

$$\sqrt{125 \times 125 - 99 \times 99} = 76.4 = BC.$$

Then for the ∠ at A. See Theo. VI.

As 125 + 49.5 : 86 : 76.4 : : 37.6 = 37° 40 the ∠ at A.

N. B. Thus alſo may caſe 5th. and 6th. be ſolved.

NAVIGATION.

Definition I.

NAVIGATION comprehends the guiding and directing a ſhip upon the ocean, from one place to another, out of ſight of land, and alſo to compute the ſhip's way on the ſea, ſo as to point out the latitude and longitude in, at any propoſed time; and alſo at any time to diſcover what courſe to ſteer, and how far diſtant from any port.

II. Latitude of a place or of a ſhip at ſea, is the neareſt diſtance of that place or ſhip to the equinoctial line, reckoned in degrees and minutes, but cannot exced 90 degrees.

N. B. The poles are 90 degrees from the equinoctial line or equator.

III. The terraqueous Globe, conſtituted of land and water, is nearly of a ſpherical form, proved by the following obſervations.

1ſt. Men on board a ſhip at ſea, may be out of ſight of land, when that land is near enough to be viſible, if it were not hid from the eye by the convexity of the water.

2d. The higher the eye is elevated above the ſurface of the earth or ſea, the further the view will be extended, as ſailors from the top of the ſhip's maſt, diſcover land or other ſhips at greater diſtance, than they can do upon deck.

3d. To thoſe that ſtand upon the ſhore, the higheſt parts of a ſhip are viſible to the greateſt diſtance; for if we obſerve ſhips ſailing from the land, firſt we loſe ſight of the hulls, then of the low ſails, and laſt of the topſails.

4th. Several navigators have ſailed quite round the globe.

5th. All the appearances of the heavens, both on the land and the ſea, are ſuch as they would be if the earth were a globe.

IV. As to the earth's dimenſions, it will be ſufficient for our purpoſe to call it 360 degrees about, each degree 60 miles or minutes.

V. The Equator, or as Mariners expreſſe it, (the line) is an imaginary great circle on the earth, ſurrounding it from eaſt to weſt, equidiſtant from its two poles, dividing it into two equal hemiſpheres, called north and ſouth latitude.

VI. Poles, are two imaginary points, each 90 degrees diſtant from the equator, called north and ſouth poles.

VII. Meridians, are imaginary great circles ſurrounding the globe from north to ſouth, cutting the equator at right angles, all meeting at the two poles, and every place, on the earth or ſea may be ſuppoſed to have one.

VIII. Difference of latitude, of two places is an arch of a meridian, contained between the parallels of latitude, paſſing through thoſe places, and is meaſured in degrees, and miles or minutes, 60 to a degree.

XI. Parallels of latitude, are leſſer circles parallel to the equator, conceived to be drawn from eaſt to weſt, through all the points of a meridian, from the equator to the poles.

X. Longitude of a place, is an arch of the equator, concontained between the firſt meridian (ſuppoſe that of London) and the meridian of that place, this is alſo meaſured in degrees and minutes, whereof 360 extend round the globe.

N B. It a place be to the weſtward of London, it is in weſt longitude, if to the eaſtward it is in eaſt longitude, as far as 180 degrees.

XI. Difference of longitude, is an arch of the equator contained between the meridians of any two places, or it is the angle at the pole contained between the ſaid two meridians. For every angle at the pole made by any two meridians, is meaſured by an arch of the equator contained between the ſaid meridians.

XII. Departure in plain ſailing, is the whole eaſting or weſting, a ſhip continually makes during any ſingle courſe, paſſing from one meridian to another.

XIII. Meridional diſtance, or difference of meridians, of any two places of different latitudes and longitudes, if reckoned in the greater latitude, is leſs than a ſhip's departure ſailing from place to place; but if reckoned in the leſs latitude, it is greater than the ſaid ſhip's departure, which is conſtant on two oppoſite points when the diſtance is the ſame

XIV. Courſe at ſea, is the angle that a ſhip's way makes with the meridian.

XV. Rhumb, or rhumb line at ſea, is the track a ſhip deſcribes during one courſe, this track croſſes all meridians at equal angles, conſequently is a ſpiral line upon the ſurface of the globe, continually approaching the pole; except ſailing eaſt or weſt, when it coincides with a parallel, and north or ſouth coinciding with a meridian; in the former caſe the ſhip approaches not the pole, and in the latter ſhe approaches it directly.

Prop. 1ſt. The latitudes of two places given, to find their difference of latitude.

Caſe 1ſt. If the places are both on the ſame ſide of the line, that is both in north or both in ſouth latitude, their difference is the diff. of latitude.

Admit cape Finiſter in latitude 43 6 north
And cape Henry in 37 0 north

Subtracted gives 6 6 = 366 miles
the difference of latitude required.

Caſe 2d. If the places are on contrary ſides of the line, one in north and the other in ſouth latitude, their ſum is the difference of latitude.

Admit Madagaſcar Iſl. in lat. 20 00 ſouth
And Madeira Iſl. in 32 17 north

um 2 17 = 3137 m.
their difference of latitude, which was required. *Prop*

Prop. 2d. The latitude of a place ſailed from, and a ſhip's difference of latitude therefrom given, to find the latitude ſhip.

Caſe 1ſt. In north latitude ſailing northerly, or in ſouth latitude ſailing ſoutherly, the ſhip goes from the line, and the difference of latitude adds to the latitude ſailed from, for the latitude ſhip.

Admit a ſhip ſails from cape Clear in Ireland in latitude 51 10 north; northerly until her difference of latitude be 132 miles, required the latitude ſhip?

To latitude cape Clear	51	10 north
Add difference latitude 132 =	2	12 north
Latitude ſhip	53	22 north

Caſe 2d. In north latitude ſailing ſoutherly, and in ſouth latitude ſailing northerly, ſubtract the difference of latitude from the latitude ſailed from, and you have the latitude ſhip, ſo long as the latitude ſailed from exceeds the difference of latitude, but if the difference of latitude be greater, ſubtract the latitude ſailed from, from the ſaid difference of latitude, and you have the latitude ſhip, of a contrary name to that ſailed from, for the ſhip has croſſed the line.

Admit a ſhip ſails from the Iſland Borgo latitude 60° 40 north, until her difference of latitude be 250 leagues to the ſouthward, required the latitude ſhip?

From Borgo latitude	60°	40 north
Subtract diff. of latt. 250l.	12	30 ſouth
Latitude ſhip	48	10 north

Again admit a ſhip ſails from the Iſland Borneo in 1° 32 north latitude, ſoutherly until their difference of latitude be 52 leagues, required the latitude ſhip?

From diff. of lat. 52 leagues =	2°	36 ſouth
Subtract lat. of Borneo =	1	32 north
Latitude ſhip	1	04 ſouth

PLAIN SAILING, or ſailing without regard to longitude.

In Plain Sailing there are three varieties.

1ſt. Meridional Sailing, or ſailing due north or ſouth upon a meridian, then the diſtance ſailed, is the difference of latitude, and as the ſhip's way makes no angle with the meridian, there can be no departure.

2d. EQUATORIAL SAILING, or ſailing due eaſt or weſt under the equinox or on the equator, or line, then the diſtance ſailed is all departure, and there is no difference of latitude, in this caſe the departure is equal to the difference of longitude.

3d. LOXODROMIC SAILING, or when ſailing on any intermediate point or rhumb, we muſt conceive a triangle formed A BC, *Pl.* 2. *Fig.* II. in which A repreſents the place ſailed from, C the place ſailed to; the hypothenuſe A C the diſtance ſailed, the leg A B the difference of latitude, the other leg B C the departure, the ∠ at A the courſe, and the ∠ at C the compliment of the courſe.

Lemma 1*ſt*. If the courſe and compliment of the courſe be equal (*viz.*) four points from both the meridian and parallel, the difference of latitude and departure will alſo be equal, whatever the diſtance be.

2*d*. If the courſe be leſs than four points, the difference of latitude will be greater than the departure.

3*d*. If the courſe be more than four points, the departure will exceed the difference of latitude.

4*th*. In the north eaſt and north weſt quarters, the courſe reckons from north, and in the ſouth eaſt and ſouth weſt quarters, it reckons from ſouth.

5*th*. The compliment of the courſe, is what the courſe wants of eight points, or quarter of the compaſs.

6*th*. The mariners compaſs conſiſts of four quarters, each eight points or 32 in the whole, correſponding to 360 degrees in a great circle, or 90 in a quarter.

Whence $\frac{90^\circ}{8} = 11^\circ\frac{1}{4} = 11^\circ\ 15 = 1$ point of the compaſs.

7*th*. *To turn Rhumbs or Points into Degrees.*

Multiply 11° 15 by the rhumbs or points propoſed, thus, let N. E. by E. or 5 points be turned into degrees?

$11^\circ\ 15\text{m.} \times 5 = 56^\circ\ 15\text{m.}$ anſwering to N. E. by E.

Again let W. N. W $\frac{3}{4}$ W, or 6 $\frac{3}{4}$ points be turned into degrees.

1 point

1 point is	11°	15m.
Which ×		6 $\frac{3}{4}$
6 points =	67	30
$\frac{1}{2}$ point =	5	37 30
$\frac{1}{4}$ do. =	2	48 45
W. N. W. $\frac{3}{4}$ W. = 6 $\frac{3}{4}$ =	75	56 15

But in calculation 75 56 is ſufficient.

8th. *To turn Degrees and Minutes into Points*

Divide by 11° 15m. and the quotient is points.

Let 75° 56m. be turned into points?

11° 15)75 56(6 $\frac{3}{4}$ points nearly.

67 30

Remainder 8 26 × 4 = 33 44

33 45

In this VARIETY *are ſix* CASES.

CASE 1ſt. Courſe and diſtance run given; to find the difference of latitude and departure.

Suppoſe a ſhip ſails 150 miles N. E. be N. $\frac{1}{2}$ E, required the difference of latitude and departure?

Sol. 1ſt. Geometrically by the plain Scale, Pl. 2. Fig. II.

Draw A B the meridian; make the ∠ at A 3 $\frac{1}{2}$ points, hen make A C = 150 miles from a ſcale of equal parts, rom C let fall a perpendicular as C B on A B, then A B meaſured on the ſcale A C was taken from is the difference of latitude 116 miles, and B C 95 miles the departure.

2d. *By Logarithms, for departure B C.*

As radius or ſine	90° 00m.	10.00000
: diſtance A C	150m.	2.17609
: : Sine of courſe	39° 22m.	9.80228
: Departure B C	95m.	1.97837

For

For Diff. of Latitude A B. by Log.

As radius or	90° 00m.	10.00000
: Diſtance A C	150m.	1.17609
: : Sine comp. courſe	50° 38m.	9.88823
: Diff. of lat. A B	116m.	2.06432

N. B. In working proportions by log. add the log. of the ſecond and third terms, and from that ſum ſubtract the log. of the firſt term, and the remainder is the log. of the fourth term or anſwer.

3*d. By* GUNTER's *Scale with Compaſſes, on the line of Sines and Numbers, for departure B C.*

As ſine 90 00 : 150 : : ſine 39 22 : 95 = B C.

Extend from the firſt term 90 00 to the third term 39 22 on the line of ſines, and that extent ſet from 150 on the line of numbers the ſame way (which always obſerve) falls on 95 the departure.

For difference of Latitude.

As Sine 90 00 : 150 : : Sine 50 38 : 116 = A B.

Here the extent from the firſt term, to the third on the line of ſines, reaches the ſame way from the ſecond term, to the fourth on the line of numbers.

4*th. By* GUNTER's *Scale with Compaſſes, on the line of Rhumbs and Numbers.*

First, for Departure.

As ſine 8 points : diſtance 150 : : ſine 3 and a half points : 95 the departure.

Second, for difference of Latitude.

A ſine 8 points : diſtance 150 : : ſine 4 and a half points : difference of latitude 116.

Here you may extend from the firſt term to the third on the ſines of the rhumbs, and that extent will reach the ſame way, from the ſecond term to the fourth or anſwer. This method is general.

Or thus, extend from ſine 8 points to the diſtance 150 on the line of numbers, and that extent ſet on ſine of courſe 3 and a half points, falls on 95 miles the departure on the line of numbers.

And the ſame extent ſet on ſine compliment of courſe 4 and a half points, falls on the difference of latitude 116 m. on the line of numbers, and ſo for others.

5th. *By the table of Natural Sines.*

Natural ſine of 3 and a half points is .634 and Ditto of Compliment of courſe 4 and a half = .772.

∵ 1 : 150 : : .634 : 95 the departure, for 150 × .634 = 95 1 miles.

Alſo, 1 : 150 : : 772 : 116 m. the difference latitude for 150 × .772 = 115.8 miles.

6th. *By* GUNTER's *Scale with Compaſſes, on the line of numbers only.*

See the proportions in the fifth of this caſe above, and extend on the line of numbers as directed by the general method in the fourth hereof.

7th. *By Mr.* MARTIN's *ſliding Rule, for departure and difference of latitude.*

	Radius.	Diſt.	S. Cou.	Dep.
As	90 00 :	150 m. : :	39 22 :	95 miles
			S. Com. C.	Diff. of lat.
And	90 00 :	150 : :	50 38 :	116

Set ſine 90 the firſt term on the ſlider, to 150 the ſecond term on the rule, then againſt ſine 39 22 the third term, on the ſlider ſtands 95 the departure on the rule; and alſo againſt ſine 50 38 on the ſlider, ſtands 116 the difference of latitude on the rule.

8th. *By Mr.* MARTIN's *ſliding Rule, on the line of numbers only.*

See the fifth, ſet the firſt term on the ſlider, to the ſecond term on the rule, then againſt the third terms on the ſlider, ſtand the anſwers or fourth terms on the rule.

9th. *By the Traverſe Table,*

Find the courſe 3 and a half, at the top of the table of difference of latitude and departure, then againſt 150 the diſtance ſailed, under lat. ſtands 115.9 the difference of latitude, and under dep. ſtands 95.1 the departure, which was required.

10*th*. *Arithmetically.*

1ſt. for the departure.

Courſe N. E. by N. $\frac{1}{2}$ E = 39° 22 = 39.36 degrees.

As $\frac{57.3}{39.36} + \frac{39.36 \times 3}{1000}$: 1 : : 150 : 95 departure.

2*d*. *For difference of Latitude.*

As 1 : 1 — $\frac{1.5 \times 39.36 \times 39.36}{10000}$: : 150 : 115.1 the difference of latitude.

Or thus after departure is found, by the ſquare root.

$\sqrt{150 \times 150 - 95 \times 95} = 116$ difference of latitude.

Case 2d. Courſe and difference of latitude given, to find diſtance and departure.

Admit a ſhip ſails N. E. by N. $\frac{1}{2}$ E. until the difference of latitude be 116 miles, required the diſtance and departure.

Sol. 1*ſt*. *Geometrically Plate* 2. *Fig*. II.

Draw A B the meridian = 116 miles the difference of latitude, from a ſcale of equal parts, make an ∠ at A = 3 $\frac{1}{2}$ points, at B raiſe a perpendicular to meet A C, then will A C meaſure the diſtance 150 m. and B C 95 the departure, on the ſcale that A B the difference of latitude was taken from.

2*d*. *By Logarithms, for diſtance.*

As ſine comp. of courſe 4 $\frac{1}{2}$ points, or		50 38 —	9.88823
: difference of latitude A B		116m.	2.06445
: : radius	8 points, or ſine	90 00	10.00000
: diſtance ſailed A C		150m.	2.17622

For departure as in Caſe the 1ſt.

3*d*. *By Scale and Compaſſes. A general rule.*

Extend from the firſt term, to the third, and that extent ſet the ſame way from the ſecond, falls on the fourth or anſwer.

4th. By Mr. MARTIN's *ſliding Rule. A general rule.*

Set the firſt term on the ſlider, to the ſecond term on the rule, then againſt the third term on the ſlider, ſtands the fourth or anſwer on the rule.

CASE 3d. Courſe and departure given, to find diſtance and difference of latitude.

Admit a ſhip ſails N. E. by N. $\frac{1}{2}$ E. until her departure be 95 miles, required the diſtance ſailed and difference of latitude.

Sol. 1ſt. Geometrically. Plate 2. Fig. II.

Draw the Meridian A B, at B raiſe a perpendicular, on which ſet from B, the departure 95m. to C, then at C make an angle of 4 $\frac{1}{2}$ points the compliment of the courſe, and produce C A to cut the meridian in A, then A C meaſured on the ſcale B C was taken from is 150m. the diſtance, and AB the difference of latitude meaſures 116 m.

2d. By Logarithms, for diſtance A C.

As ſine of courſe 3 $\frac{1}{2}$ points, or	39° 22 —	9.80228
: departure B C	95m.	1.97837
: : radius 8 points, or ſine	90 00	10.00000
: diſtance A C	150m.	2.17609

For difference of latitude A B, ſee the ſecond of Caſe 1ſt.

3d. By natural Sines for diſtance.

Per table the natural ſine of 3 $\frac{1}{2}$ points is .634 and of 4 $\frac{1}{2}$ = .772.

∵ As .634 : 95 : : 1 : 149.8 or 150 nearly.

For the Difference of Latitude.

As .634 : 95 : : .772 : 115.7 nearly.

4th By Scale and Compaſſes, and by ſliding Rule; as directed in the 2d. Caſe.

CASE 4th Diſtance and departure given, to find courſe and difference of latitude.

Admit a ſhip ſails into the N. E. quarter 150 miles, and have made 95 miles departure, required the true courſe and difference of latitude?

Sol. 1ſt. Geometrically. Plate 2. Fig. II.

Draw a meridian or north and ſouth line, at a point as B, raiſe a perpendicular to the right hand, becauſe the courſe is into the N. E. quarter, then ſet thereon 95 = B C, then with 150 in your compaſſes as a radius ſet one foot in C, and with the other ſtrike an arch to cut the meridian in A, the place ſailed from, draw A C, and its done, for the ∠ at A meaſured on the ſcale of rhumbs is 3 $\frac{1}{2}$ points, the courſe from the north eaſterly or N. E. b. N. $\frac{1}{2}$ E. alſo A B meaſures the difference of latitude 116 m.

2d. By Logarithms, for courſe.

As diſtance run A C - - - - -	150	m.	2.17609
: Radius 8 points, or ſine - - - -	90	00	10.00000
: : Departure B C - - - - - - -	95	m.	1.97772
: Sine of courſe 3 and a half points, or	39	18	9.80163

For difference of latitude as per caſe firſt.

3d. By natural Sines, for Courſe.

As 150 : 1 : : 95 : .633 anſwering in the table to 3 and a half points, or N. E, by N. half E.

4th. Arithmetically, for difference of Latitude.

$\sqrt{150 \times 150 - 95 \times 95} = 116$ the difference of latitude.

For Courſe.

As $150 + \frac{116}{2} : 95 : : 86 : 39.27$ degrees = 39 16 = 3 and a half points, as before.

Or thus, As $150 + \frac{116}{2}$ 95 : : $7\frac{2}{3}$: $3\frac{1}{2}$ points. or, As 208 : 95 : : 7.6 : 3.5 as before.

Case 5th. Diſtance and difference of latitude given; to find courſe and departure.

Admit a ſhip ſails into the S. W. quarter 184 miles, and has made 120 miles difference of latitude, required the true courſe and departure.

Sol. 1ſt. Geometrically. Pl. 2. *Fig.* III.

Draw a meridian line, and at a point as at B, raiſe a perpendicular to the left hand ſide of that line, becauſe the courſe is weſterly, ſet the difference of latitude 120 miles from B upwards to A, then with the diſtance in the compaſſes 184 miles, and one foot on A, cut the perpendicular in C, draw A C and its done; for the ∠ at A meaſured on the rhumbs is the courſe 4 and a half points or S. W. half W; and B C meaſures 139.4 the departure.

2d. By Logarithms, for Courſe.

As diſtance A C -	184	00	2.26481
: Radius 8 points, or ſine -	90	09	10.00000
: : difference of latitude A B	120	09	2.07918
: Sin. Com. cou. $3\frac{1}{4}$ points, or	40	42	9.81437
Which ſubtract from 8 points, or	90	00	
Courſe $4\frac{1}{2}$ or South	49	18 W.orS.W. $\frac{1}{2}$ W.	

For departure as in Caſe 1ſt.

3d. By Natural ſines, for Courſe.

A 185 : 1 : : 120 : .648 Anſwering in the table to 3 and a half points. And 8 points — 3 and a half = 4 and a half = S. W. half W, the courſe.

For the Departure.

$\sqrt{1 - \overline{.648} \times \overline{.648}} = 76$ the natural ſine of 49 deg. 10 minutes, or 4 and a half points nearly.

Then, As 1 : 184 : : .76 : 139.8 = B C the departure

4th. Arithmetically, for Departure B C.

$$\sqrt{184 \times 184 - 120 \times 120} = 139.8 = \text{B C.}$$

Then for Courſe.

As $184 + \frac{139.8}{2}$: 120 : : 72 : 3.6 that is $3\frac{1}{2}$ points nearly, and its compliment $4\frac{1}{2}$ points, S.W. $\frac{1}{2}$ W, is the courſe.

Case 6th. Difference of latitude and departure given, to find courſe and diſtance.

Admit a ſhip ſails into the S. W. quarter, until her difference of latitude be 120 miles, and her departure 140 m. query the true courſe and diſtance.

Sol. 1ſt. Geometrically. Pl. 2d. Fig. III.

Draw the meridian A B = 120 miles the difference of latitude, at B raiſe a perpendicular to the left hand ſide, becauſe the courſe is S. Weſterly, make B C = 140 the departure, join A C, which is the diſtance 184 miles; and the ∠ at A meaſured on the ſcale of rhumbs is 4 and a half points nearly, the courſe S. W. half W, which was required.

2d. By Logarithms, for Courſe.

As diff. of lat. A B	120m.	log.	2·07918
: Tangent of radius	45 00		10.00000
: : Departure B C	140m.		2.14612
: Tangent of courſe	49 24		10.06694

Or $4\frac{1}{2}$ points nearly = S.W. $\frac{1}{2}$ W.

For Diſtance by Logarithms.

As ſine of the courſe	49 24	9.88039
: Departure B C	140m.	2.14612
: : Radius or ſine	90 00	10.00000
: Diſtance A C	184 m	2.26573

3d. By Scale and Compaſſes, for Courſe.

By the general rule, extend from the 1ſt. term 120m. to the third term 140 on the line of numbers, and that extent ſet on the tangent 45° the ſecond term, falls on 49 24 increaſing on the line of tangents, or the aforeſaid extent ſet on tangent of 4 points, reaches near $4\frac{1}{2}$ points on the tangent of rhumbs, the courſe, then for diſtance as before directed.

4th. By Mr. MARTIN's *ſliding Rule, for Courſe.*

Set 120 on the ſlider, to 140 on the rule on the line of numbers, then againſt tangent 45 on the rule, ſtands tangent of 49 24 for the courſe on the ſlider, then for diſtance as in caſe 1ſt.

5th. By natural tangents &c. for Courſe.

As 120 : 1 : : 140 or as 6 : 1 : : 7 : 1.16 anſwering in the table to 49 24 or $4\frac{1}{2}$ points nearly S. W. $\frac{1}{2}$ W. the courſe.

6th. Arithmetically, for Diſtance.

$\sqrt{\overline{120\times120}+\overline{140\times140}}=184$ miles the diſtance A C.

For Courſe as in Caſe 5th.

TRAVERSE SAILING.

TRAVERSE SAILING, is when a ſhip, by reaſon of the wind ſhifting, or for other cauſes, ſails on ſeveral courſes, in given periods of time.

To reſolve a traverſe, is to order and compound the ſeveral courſes and diſtances, obtained by the compaſs, log and half minute glaſs, ſo that it may be known at ſtated periods of time, taken at pleaſure, the place the ſhip is in, that is which way, and how far from the place ſailed from, alſo what courſe to ſail, and how far diſtant at that time from the port bound to.

To Conſtruct any Traverſe Geometrically, by the plain Scale. Plate 2. Fig. IV.

I. Draw the meridian line as A B, make an angle at A, the place ſailed from towards the right hand if the courſe be eaſterly; upwards if northerly, but downwards if ſoutherly, or towards the left hand if the courſe be weſterly; upwards if northerly, downwards if ſoutherly.

II. Set the firſt diſtance taken from a convenient ſcale of equal parts from A to 1.

III. At 1 make an angle m 1 2 equal to the angle between the firſt and ſecond courſes, to the right or left hand ſide, looking forwards always the way the ſhip ſails, according as the ſhip is made to alter to the right or left hand ſide by means of the rudder.

IV. Set on that line the ſhip ranges on, the diſtance run out by the log on the ſecond courſe, as from 1 to 2; proceeding thus, with every courſe and diſtance, as they occur to the end of the traverſe, as at C.

V. From C let fall the perpendicular C B upon the meridian ſailed from, ſo is C B the true departure, A B the difference of latitude, A C the diſtance from the place ſailed, each of which meaſured on the ſame ſcale, that the particular diſtances were taken from, ſhews their reſpective quantities, and the angle B A C is the courſe, meaſurable on the ſcale of rhumbs.

Or otherwiſe thus. Pl. 2. *Fig* V.

I. Having drawn the meridian A B, and laid down the firſt courſe, and diſtance as aforeſaid.

II. Through 1 the then place of the ſhip, draw a line parallel, to the meridian of the place ſailed from A B, which becomes a new meridian, from which lay down the 2d. courſe and diſtance, and ſo proceed to the end.

III. If you then compleat the ſeveral triangles as A 1 *a*, 1 *b* 2. 2 *c* 3. 45 *d* &c. as per fig you have the difference of latitude and departure to each reſpective courſe.

IV. Then if all the departures on the ſame ſide, of the reſpective meridians as the firſt, be meaſured and called poſitive, and alſo thoſe on the contrary ſide, meaſured and called negative.

V. If the ſum of the poſitive departures exceed the ſum of the negative ones, their difference is the true departure, and the ſhip is on the ſame ſide the firſt meridian ſailed from, as was the firſt courſe; but if the ſum of the negative departures be greater, their difference is the true departure, and the ſhip is on the contrary ſide of the meridian ſailed from, on the firſt courſe.

VI. The differences of latitude of the ſame quality as the firſt, may be called poſitive, and theſe on the contrary negative, then the difference of the ſums of the poſitive and negative ones, is the true difference of latitude.

VII. If the ſum of the poſitive, exceed the ſum of the negative, the ſhip is on the ſame ſide the port ſailed from, in reſpect to north or ſouth, as after the firſt courſe; but if the ſum of the negative be greater, the ſhip is on the contrary ſide, with reſpect to the firſt courſe.

VIII. In fig. V. the departures, *a* 1. *b* 2. *c* 3. *d* 5. *e* 6. *g* 9 and *h* C are poſitive, and the departures, 67, and 8*f*, are negative, therefore, $a\,1. + b\,2. + c\,3. + d\,5. + e\,6. + g\,9 + h\,C. - 67. - 8f = BC$, the true departure on the ſame ſide the meridian A B as *a* 1, becauſe, the poſitive are greater; if the negative had been greater, it is evident the place of the ſhip at C, muſt have been on the contrary ſide of the meridian ſailed from A B.

IX. The ſeveral differences of latitude $A\,a + 1\,b + 2\,c + 3\,4 + 4\,d + 7\,f + 8\,g + g\,h$ are all poſitive, and only 5 *e* negative, which is much leſs than the former, whence the ſhip at C, is to the ſouthward of A, according to the firſt courſe, but if the negative difference of latitude had exceeded the poſitive, then the place C had been to the northward of A, contrary to her firſt direction.

Admit a ſhip ſails from a port A the following courſes and diſtances (viz.)

	m.		m.		m.
E. S. E.	45	S. S. E.	36	E. S. E. half E.	30
South	42	S. E. by S.	64	N. by E. half E.	50
Weſt	72	S. S. W.	35	S. S. E. half E.	37

And S. E. by E $\frac{3}{4}$ E. 40 required the true courſe and diſtance from the place ſailed from.

Sol.

Sol. 1ſt. By the Traverſe Table.

In the table under or over the reſpective courſes according as they are found at top or bottom of the pages, and againſt their ſeveral diſtances, are the differences of latitudes and departures, in their reſpective columns as may be obſerved in the ſubjoined table.

A Traverſe TABLE *of the Laſt* QUESTION.

Courſes Steered.	Diſt. run.	Working points.	Drawing Points.	diff. of lat.		Departure.	
				N.—	S. +	E. +	W.—
E. S E.	45	6	6	00	17.2	41.6	00
S S. E.	36	2	4	00	33.3	13.8	00
E. S. E. ½ *E.*	30	6½	4½	00	8.7	28.7	00
South	42	0	6½	00	42	00	00
S E. by *S.*	64	3	3	00	53.2	35 6	00
N. by *E.* ½ *E.*	50	1½	11½	47.5	0	14 5	00
Weſt	72	8	9½	00	00	0	72
S. S. W.	35	2	6	00	32.3	0	13.4
S. S. E. ¼ *E.*	37	2¼	4¼	00	33 4	1 8	00
S.E by *E.* ¾ *E.*	40	5¾	3½	00	17	3 2	00
N. B. N. — ſtands for north negative, S. + for ſouth poſitive E. + for eaſt poſitive W. — for weſt negative.				47.9	237.2	186.2	85.4
					7.9	85 4	
				½	189.3	100.8	
					94.6	50.4	

Then with half difference of latitude 94.6 and half th departure 50.4, per traverſe table the courſe is 2 points an a half or S. S. E. half E. diſtance 215 miles.

II. *Or thus by Natural Sines, Coſines, &c.*

	N. B. N. S. C. ſtands for Natural Sine of Courſe.	And N. S. C. C ſtands for Nat. ſine. Compliment Courſe
Courſes.	Diſt. × N. S. C. = Departure.	Diſt. × N. S. C. C. = diff. of lat.
E S. E.	45 × .92 = 41.4 +	45 × .38 = 17.1 +
S. S E.	36 × .38 = 13.6 +	36 × .92 = 33.1 +
E. S. E. ½ E.	30 × .96 = 28.8 +	30 × .29 = 8.7 +
South.	42 × 0 = 0	42 × 1 = 42 +
S. E. by S.	64 × .55 = 35.2 +	64 × .83 = 53.1 +
N. by E. ½ E.	50 × .29 = 14.5 +	50 × .96 = 48 —
West.	72 × 1 = 72 —	72 × 0 = 0
S. S. W.	35 × .38 = 13.3 —	35 × .92 = 32.2 +
S. S. E. ¼ E.	37 × .43 = 15.9 +	37 × .9 = 33.3 +
S. E. by E. ¾ E.	40 × .9 = 36. ×	40 × .43 = 17.2 +
	185.4 +	236.7 +
	85.3 —	48. —
	departure 100.1 +	diff. lat. 188.7 +

In this table the difference of latitudes and departures marked + are poſitive or agreeing with the firſt, and theſe marked — are negative or contrary.

For courſe by natural tangents.

As 188.7 : 1 :: 100.1 : .53 correſponding to the natural tangent of 2 points and a half nearly, or 27° 55 nearer, anſwering to S. S. E. half E.

For diſtance ſailed.

As natural ſine courſe .468 : 100.1 :: 1 : 214 miles.

3d. Inſtrumentally by Scale and Compaſſes.

Extend from S· of 8 points or radius, on the line of rhumbs, marked S. R. for ſine of rhumbs, to the firſt diſtance 45m. on the line of numbers, marked num. and that extent ſet from courſe 6 points, on the line S. R, will reach to 41.4 on the line of numbers, the departure; alſo that ſame extent ſet on compliment of courſe 2 points on the ſaid line S. R, reaches to 17.1 the difference of latitude on the line marked numb. thus proceed, with each courſe and diſtance, and place the departures and difference of latitudes, as in the firſt table.

Then for Courſe and Diſtance.

Extend from the difference of latitude 189 to 100 the departure on the line of numbers, (which we ſhall call Gunter's line) and that extent ſet on 4 points on the tangent of rhumbs marked T. R. reaches to 2 and a half points on the ſaid tangent line.

Or it will reach from tangent of radius 45° on the line marked tan. to the tangent of 27 55 nearly the courſe in degrees.

For diſtance thus.

Extend from ſine 27 55, to radius or ſine 90° and that extent will reach from 100.1 on gunter's line to 214 miles the diſtance required.

4th. By GUNTER's *line of numbers only, with the aſſiſtance of natural ſines, &c. ſee the laſt table.*

Extend from 1 to the diſtance 45m. and that extent reaches from N. S. of courſe .92 to 41.4 the departure, alſo the ſame extent reaches from .38 the N. co. ſine of courſe, to 17.1 the difference of latitude, thus, you go on to find the departure, and difference of latitude to each courſe and diſtance.

Then for courſe made good.

Extend from difference of latitude 189 to departure 100, and that extent ſet on 1 falls on .53 correſponding to the natural tangent of 27 55 or 2 points and half anſwering to S. S. E. half E. as before.

For diſtance made good.

Extend from natural ſine of courſe, .47 to 1, and that extent reaches from departure 100 to 214 the diſtance required.

5*th*. *By ſliding rule, on Numbers, Sines, Tangents, &c.*

Set the diſtance 45m. on the ſlider, to S. of 8 points on the rule, then againſt ſine of courſe 6 points on the rule, ſtands 41.4 the departure on the ſlider ; alſo then againſt 2 points the compliment of the courſe on the rule, ſtands 17.1 the difference of latitude on the ſlider, ſee the former table, and thus proceed with every courſe and diſtance, and place the departures and differences of latitude as before directed.

For courſe Steered, or bearing of the Port A.

Set the difference of latitude 189 on the ſlider, to 100 the departure on the rule, then againſt tangent of radius 45° on the ſlider, ſtands tangent of 27° 57 on the rule, anſwering to 2 points and a half or S. S. E. half E. nearly.

For diſtance to or from Port A.

Set ſine of 27 57 or ſine of 2 points and a half on the ſlider, to the departure 100 m. on the line of numbers on the rule, then againſt ſine 90° or ſine of 8 points on the ſlider, ſtands 214 m. the diſtance on the rule.

6*th*, *By the common ſliding rule, on* GUNTER's *line of numbers only.*

Take out of your table of natural ſines, &c. the ſine and co. ſine of every courſe, which put down as in the latter table, then, ſet 1 on the ſlider, to the diſtance 45m. on the rule, and againſt .93 on the ſlider ſtands departure 41.4 on the rule, alſo againſt .38 on the ſlider, ſtands the difference of latitude 17.1 on the rule &c.

Having thus found all the differences of latitudes and departures with the true difference of latitude 189m. and true departure 100m. nearly.

To find the courſe or bearing of Port A. Pl. 2. Fig V.

Set the difference of latitude 189 on the ſlider, to the departure 100 on the rule, then againſt 1 on the ſlider, ſtands .53 on the rule, the natural tangent of 27 57 or 2 and a half points or S. S E. half E. nearly.

To find diſtance to or from port A.

Set natural ſine of courſe 2 and a half = .47 on the ſlider, to 100 the departure on the the rule, then againſt 1 the natural radius on the ſlider, ſtands 214 the diſtance nearly, on the rule.

7th. Arithmetically.

N. B. To reſolve a traverſe by arithmetic, you muſt work with the leſs angle, be it courſe or its compliment, and find the leſs leg firſt, whether departure or difference of latitude; ſee caſe 1ſt. plain ſailing.

In the preceeding queſtion, the compliment of the firſt courſe is the leſs angle.

Therefore to find the difference of latitude or leſs leg.

Compliment of courſe 22 30 = 22.5. = 2 points

$$\text{As } \frac{57.3}{22.5} + \frac{22.5 \times 3}{1000} : 1 :: 45 : 17.2 \text{ the diff. of lat.}$$

Which contracts to the following proportion.

$$\text{As } \frac{5.09}{2} + \frac{2 \times 3}{88.8} : 1 :: 45 \text{ diſtance} : 17.2$$

To find the Departure or greater Leg.

$$\text{As } 1 : 1 - \frac{15 \times 22.5 \times 22.5}{10000} :: 45 : 41.5$$

Which admits of the following contraction.

$$\text{As } 1 : 1 - \frac{2 \times 2}{52.6} :: 45 : 41.5$$

Again the laſt courſe but one is S. S. E. a quarter E. or 2 and a quarter = 2.25 points, therefore,

To find the departure or leſs leg.

As $\frac{5.09}{2.25}+\frac{2.25\times 3}{88.8}$: 1 : : 37 diſtance : 15.7 departure.

Then for Difference of Latitude.

As $1 : 1 \frac{2.25 \times 2.25}{52.6} :: 37 : 33.5$

Or $\sqrt{\overline{37\times37}-\overline{15.7\times15.7}} = 33.5$ the diff. of lat.

Thus proceed to find the difference of latitude and departure, correſponding to each courſe and diſtance, in the queſtion, whence the difference of latitude is 189m. and the departure 100 m. then,

To find the diſtance.

$\sqrt{\overline{189\times189}+\overline{100\times100}} = 214$ nearly.

To find Courſe.

diſt. $\frac{1}{2}$ dif. lat. dep.

As $214+\frac{189}{2} : 100 :. 86 : 27.9$ nearly = 27° 54 S. Eaſterly.

Or as $214+\frac{189}{2} : 100 :: 7\frac{2}{3} : 2.5$ nearly or 2 points and a half anſwering to S. S. E. half E.

PARALLEL SAILING

THIS is ſailing due eaſt or weſt, on ſome parallel of latitude, in which longitude is to be conſidered, therefore it may be premiſed antecedent to the caſes of parallel ſailing, that all the parallels of latitude, from the equator to the poles, gradually decreaſe until they vaniſh at the pole, whence it follows, that, as 60 miles make a degree of longitude on the equator, and that the ſame number of degrees, are reckoned on every parallel of latitude; ſo that every degrre of longitude decreaſes from 60 miles at the equator to 0 at the poles, and this decreaſe is, as the Co. ſines of the parallels of latitude, or as the ſines of the diſt. of the parallels of latitude from the neareſt pole, whence ſpring the origin of the following caſes.

Firſt of Rules Reſpecting Longitude.

PROBLEM I. The longitudes of two places given, to find their difference of longitudes.

RULE 1ſt. If the two places be both in eaſt, or both in weſt longitude, their difference is their difference of longitude.

Admit A in longitude 47 18 W. And B in longitude 45 29 W. required their difference of longitude?	From 47 18 W. Sub. 45 29 W. M. 109 = 1 49 Anſ.

RULE 2d. If one place be in eaſt and the other in weſt longitude, their ſum if under 180 degrees, is their difference longitude.

Admit A in longitude 6 8 Weſt and B in longitude 2 5 Eaſt, required their difference of longitude?	To 6 8 W. Add 2 5 E. M. 493 = 8 13 Anſw.

RULE 3d. If the ſum of the longitudes exceed 180 degrees, the ſupplement of their ſum to 360 degrees is the tr difference of longitude.

Admit A in lon. 173 48 E. And B in 178 15 Weſt, required their difference of longitude?	To 173 48 E. Add 178 15 W. Sum 352 3 Sub. from 360 0

Miles 477 = 7 57 Anſwer.

PROBLEM II. The difference of longitude of two places, and the longitude of one place given; to find the longitude of the other.

RULE 1ſt. In Eaſt longitude ſailing eaſterly, and in Weſt longitude ſailing weſterly, add the difference of longitude to the longitude ſailed from, and the ſum if under 180 degrees is the longitude ſhip.

Admit a ſhip ſails from longitude 18 44 Weſt; a weſterly courſe until the difference of longitude be 347 miles, required the longitude ſhip?

To longitude ſailed from	-	-		18	44	W.
Add difference of longitude	-	347	=	5	47	W.
Longitude ſhip	-	-		24	31	W.

RULE 2d. But if the ſum in the preceeding rule ſhould exceed 180 degrees, ſubtract it from 360 degrees, and the remainder is the longitude of a contrary name to that ſailed from.

Admit a ſhip ſails from the longitude 175° 48 weſt, weſterly until the difference of longitude be 584 miles, required the longitude ſhip?

To longitude ſailed from		175°	48	weſt
Add 584 miles		9	44	weſt
Sum -	- -	185	32	
Subtract from	- -	360	00	
Longitude ſhip	- -	174	28	eaſt anſwer.

RULE 3d. In eaſt longitude ſailing weſterly, and in weſt longitude ſailing eaſterly, ſubtract the difference of longitude, if leſs from the longitude ſailed from, and you have the longitude ſhip, of the ſame name as that ſailed from.

Admit a ſhip ſails from the longitude 48° [illegible]5 weſt, eaſterly until the difference of longitude be 278 miles, required the longitude ſhip?

From

From longitude ſailed from		48° 15	weſt
Subtract the diff. of longitude 278	=	4 38	eaſt
Longitude ſhip's in	—	43 37	weſt

Rule 4th. But if the difference of longitude be greater than the longitude ſailed from; ſubtract the latter from the former, and the difference is the longitude ſhip, contrary to that ſailed from, for then the ſhip has croſſed the firſt meridian.

Admit a ſhip ſails from the longitude 3° 47 eaſt, weſterly until the difference of longitude be 489 miles, required the longitude ſhip?

From the diff. of longitude 489m.	=	8° 9	weſt
Longitude ſailed from ſubtract		3 47	eaſt
Longitude ſhip	—	4 22	eaſt

Case 1ſt. The difference of longitude of two places in a known latitude given, to find, their parallel diſtance.

Admit a ſhip ſails in the parallel of 55° 30 until the difference of longitude be 234 miles, required the parallel diſtance, or diſtance ſailed?

1ſt. Geometrically Plate 2d. Fig VI.

Draw an eaſt and weſt line as A B = 234m. from a ſcale of equal parts; with chord 60 = ſine 90, as a radius in your compaſſes, and one foot on A make an arch, which cut, with the ſame radius, and one foot on B in the pole P, then with a radius equal to the compliment of the latitude (viz) 34 30 from the ſcale of ſines, with one foot on P, ſtrike the arch *n m*, whence the chord *n m* being drawn, and meaſured on the ſcale the difference of longitude was taken from, gives the parallel diſtance = 133 miles the anſwer.

2d. By Logarithms.

As radius or ſine A P	90 00	10
: the difference of longitude A B	234m.	2.36921
: : ſine comp. latitude *n* P	34 30	9.75312
: the parallel diſtance *n m*	133m.	2.12233

3d.

3d. *By* GUNTER *with campaſſes.*

Extend on the line of ſines from the firſt term above, (viz) 90 to the third term 34 30, and that extent ſet the ſame way, from the ſecond term 234 on the line of numbers, reaches to 133 miles the anſwer.

4th. *By natural ſines.*

Per table, the natural ſine of the compliment of the latitude 34 30 is .57,

∵ 1 : 234 : : .57 : 133 the parallel diſtance.

5th. *By ſliding* GUNTER *on the line of Numbers.*

Set 1 the firſt term on the ſlider, to .57 the third term on the rule, then againſt 234 the ſecond term on the ſlider, ſtands 133 the anſwer on the rule.

6th. *By the ſcale of Latitude and Longitude. Arithmetically.*

On the line of longitude marked M. L, againſt the latitude 55 30 on the contiguous line of chords or latitude, ſtands 34.2 the miles that make a degree of longitude in that latitude.

∵ As 60 : 234 : : 34,2 : 133 miles the anſwer.

7th. *The laſt Analogy may be done by* GUNTER *with Compaſſes, or by the ſliding* GUNTER.

CASE 2d. The parallel diſtance in a known latitude given, to find the difference of longitude.

Admit a ſhip ſails due eaſt 133 miles, in the latitude 55 30, required the difference of longitude made

1ſt. *Geometrically, Pl.* 2. *Fig.* VI.

Draw an eaſt and weſt line as *n m* by a ſcale of equal parts, then with a radius of 34 30 the compliment of the latitude, from your ſcale of ſines, with one foot on *m* ſtrike an arch, which cut with the ſame radius, and one foot on *n* in P the pole, produce the lines P *n* and P *m* indefinitely, then with radius = 90 from the ſcale of ſines, and one foot on P, ſtrike the arch A B, and the chord thereof A B meaſures the difference of longitude 234 miles, which was required.

2*d*. *By Logarithms.*

As ſine compliment of latitude -	34	30	9.75312
: The parallel diſtance - -		133m.	2.12233
: : Radius - - - - -	90	00	10.
: Difference of longitude -		234m.	2.36921

3*d*. *By* GUNTER's *ſcale with Compaſſes.*

Extend from the firſt term 34 30, to the third term 90 on the line of ſines, and that extent ſet from the ſecond term 133 the ſame way on Gunter's line of numbers, falls on 234 the difference of longitude.

4*th*. *By ſliding Gunter.*

Set the firſt term on the ſlider, to the third term on the rule, then againſt the ſecond term on the ſlider, ſtands the fourth term or anſwer on the rule.

5*th*. *By natural Sines.*

The natural ſine of 34 30 = .569.
∴ As .57 : 133 : : 1 : 234 the difference of lon. nearly.

6*th*. *By* GUNTER's *ſcale with Compaſſes.*

Extend from the firſt, to the third term, on the line of numbers, and that extent reaches from the ſecond, to the fourth term or anſwer on the ſame line.

7*th*. *By ſliding Rule on Numbers.*

Set the firſt term on the ſlider, to the third on the rule, then againſt the ſecond on the ſlider, ſtands the fouth or anſwer on the rule.

8*th*. *By lines of Latitude and Longitude. Arithmetically.*

Againſt the latitude 55 33, ſtands 34.1 the miles that make a degree of longitude there.

∴

∵ As 34.1 : 133 :: 60 : 234 the anſwer nearly.

9th. *The laſt Analogy works by* GUNTER *with Compaſſes, or ſliding Rule, on the line of numbers.*

CASE 3d. The difference of longitude, and parallel diſtance given; to find the latitude.

Admit ſailing due eaſt or weſt 133 miles, we have made 234 miles difference of longitude, required the latitude ſailed in?

1ſt. *Geometrically Plate* 2 *Fig.* VI.

Draw an eaſt and weſt line A B = 234m. the difference of longitude from a ſcale of equal parts, find P the pole as directed in caſe firſt, draw the meridians P A and P B, then ſet the parallel diſtance from A to *x* alſo at P with the ſame radius ſtrike the arch *r*, which with the radius A P and one foot on *x*, cut in *s*, draw *s x* to croſs P B in *m*, then with the radius P *m*, ſtrike the arch *m n*, ſo will *n* P = *m* P meaſured on the ſcale of ſines be 34 30, and its compliment 55 30 the latitude required.

2d. *By Logarithms.*

As difference of longitude	234m.	2.36921
: radius	90 00	10.
:: parallel diſtance	133m.	2.12233
: ſine comp. latitude	34 30	9.75312
which ſubtract from	90 00	
gives the latitude required	55 30	

3d. *By Scale and Compaſſes, ſee the* 3d. *of Caſe the* 2d.

4th. *By ſliding Rule, ſee the* 4th. *of Caſe* 2d.

By natural Sines.

As 234 : 1 :: 133 : .568 nearly anſwering to 34 30 the compliment of 55 30 the latitude required.

6th. *By the lines of Latitude and Longitude.*

As 234 : 60 :: 133 : 34.1 on the line M. L. againſt which ſtands 55 30 the latitude required.

CASE 4th. the diſtance of two ſhip's aſunder, both in the ſame known latitude being given ; to find their diſtance aſunder in another known latitude.

Admit two ſhip's both in the latitude 55 30 north diſtant aſunder 133 miles, required their diſtance aſunder when both on their reſpective meridians, in the latitude of 72 30 north?

1ſt. *Geometrically Plate* 2. *Fig*. VI.

Draw an eaſt and weſt line $m\ n$ = 133 miles, and find P the pole as directed in caſe 2d. then with a radius = ſine of 17 30 the compliment of 72 30 ſtrike the arch $a\ b$, ſo ſhall $a\ b$ meaſured on the ſcale $m\ n$ was taken from, be 70 miles their diſtance aſunder required.

2d. *By Logarithms.*

		Co. Ar.
As ſine comp. of latitude where diſtance is given	34 30	0.24688
: diſtance aſunder there	133m.	2.12233
: : ſine comp. of the other lat.	17 30	9.47814
: the diſtance aſunder there	70m.	1.84735

3d. *By* GUNTER *as before directed.*

4th. *By natural Sines, Arithmetically.*

The natural ſine of the compliment of one latitude 34 30 = .57, and of the other 17 30 is .3

$\because$ As .57 : 133 : : .3 : $\frac{13.3}{19}$ = 70. Anſwer.

5th. *By the ſcale of Latitude and Longitude.*

The miles that make a degree of latitude in 55 30 are 34.1 and in latitude 72 30 are 18.

$\because$ As 34.1 : 133 : : 18 : 70 miles. Anſwer.

6th. *By* GUNTER's *Scale, and ſliding Gunter, as before directed.*

CASE 5th. Given, the diſtance aſunder of two ſhips in a given latitude, to find the latitude where their diſtance aſunder, on the ſame meridians ſhall be alſo given.

Admit two Ships in the latitude of 72 30 N diſtant aſunder 70 miles, required in what latitude their diſtance aſunder will be 133 miles, being on the ſame meridian?

1ſt. Geometrically, Pl. 2. Fig. VI.

Draw an eaſt and weſt line as *a b* = 70 miles, and find P the pole as directed in caſe 2d. draw the meridians P *a* and P *b*, which produce indefinitely; alſo produce *a b* to *z*, ſo that *a z* may be = 133 miles, draw *z m* parallel to P *b*, to meet P *b* produced in *m*, make P *n* = P *m*, and each meaſured on the ſcale of ſines is 34, 30 the compliment of 55 30 the latitude required.

2d. By Logarithms.

		Co. Ar.
As the diſtance in the given latitude -	70	8.15491
: Sine Comp. of that latitude -	17 30	9.47814
: : The other diſtance - -	133	2.12233
: Sine compliment of latitude required	34 30	9.75538
Which ſubtract from - -	90 00	
Anſwer the latitude required.	55 30	

3d. By GUNTER, *as before directed.*

4th. By natural ſines.

Compliment of 72 30 = 17 30 natural ſine .3

∵ As 72 : .3 : : 133 : .57 the natural ſine of 34 30, its compliment is 55 30 the latitude required.

5th. By the Scale *of Latitude and Longitude.*

Againſt latitude 72 30 ſtands 18 miles to a degree of longitude there.

∵ As 70 18 133 34.2 nearly, againſt which in the line of longitude ſtands 55 30 the latitude required.

MER-

MERCATOR's SAILING.

IN this method of ſailing, the ſurface of the Globe is conſidered, as projected in plano, ſo that the meridians are ſtraight lines parallel to, and equidiſtant from each other; the parallels of latitude are alſo ſtraight lines, and parallel to one another, but the diſtance between them, increaſes from the equator towards either pole, in the ratio of the ſecants of the latitudes to the radius.

This projection altho' called Mercator's, was invented, demonſtrated, and its uſes pointed out long before, by our countryman Mr. Wright; ſome attribute the original invention to neither of theſe gentlemen, as hinted by Ptolemy about 2000 years ago.

Before we enter on the caſes of Mercator's ſailing, it may be neceſſary to premiſe ſomething of the meridional difference of latitude of two places; which admits of two varieties.

Var. 1ſt. When the places are both in north, or both in ſouth latitude, to find their meridional difference of latitude, according to Mercator's enlarged meridian projection.

Sol. 1ſt. By tables of meridional parts.

Rule. Find the propoſed latitudes in the table, againſt which are the meridional parts correſponding to theſe latitudes, and their difference is the meridional difference of latitude.

Example. Required the meridional difference of latitude between cape Clear in latitude 51 10 north, and cape Henry in latitude 37 north.

Lat. cape Clear	51 10	meridional parts	3585
D° Henry	37 00		2393
meridional difference of latitude			1192

2d. By Mercator's *line on* Gunter's *ſcale.*

Extend on the line marked meri. from 37. to 51 10. and that extent meaſured on the conjoined line (Eq. Pts.)

of equal parts gives 12 52 = 1192 the anſwer as before.

Var. 2d. When the places are one in north, and the other in ſouth latitude, to find their meridional difference of latitude.

Rule. Take out of the table the meridional parts anſwering to each latitude, and their ſum is the meridional difference of latitude.

Example. required the meridional difference of latitude between the iſland Iava in latitude 7 40 ſouth, and the iſland Barbadoes, in latitude 13 26 north?

Sol. 1ſt. By table of meridional parts.

Iſland Iava latitude	7 40 ſouth	M. P.	461
Do. Barbadoes	13 26 north	-	813
meridional difference of latitude			1274

2d. By Mercator's *line on* Gunter's *ſcale.*

Take 7 40 on the meridian line.

Which meaſured on the line Eq. P. is	7°	41
And 13 26 meaſured on ditto gives	13	33
	21	14
	60	
Meridional difference of latitude	1274 miles	

Case 1ſt. The latitudes and longitudes of two places given, to find courſe, diſtance, and departure.

Required courſe, diſtance, and departure, from A in latitude 51 0 north longitude 1 0 weſt to B in latitude 53 45 north, longitude 8 30 weſt? *Plate 2. Fig.* VII.

Preparative to Solution.

From latitude B	53 45	M. P.	3839
Subtract latitude A	51 00		3569
	2 45		270 the mer. diff. of lat.
	60		
The difference of latitude	165 miles.		

La.

Latitude A	51 00	longitude	1 0 weſt.
D° B	53 45	D°	8 30
Sum	104 45	difference	7 30
			60
Half ſum is middle lat.	52 22		
Subtract from	90 00		450 the diff. of lon.
Co. middle latitude	47 58		

1ſt. *Geometrically by* Mercator's *method.*

Draw the meridian A x = 270m. the meridional diff. of latitude, at x erect the perpendicular $x\,z$ = 450m. the diff. of longitude, make A B = 165 the difference of latitude, draw B C parallel to $x\,z$, and join z A, then will the ∠ at A meaſure the courſe on the ſcale of chords = 59 degrees, A C the diſtance 321 and B C the departure = 275m. on the ſcale of equal parts.

2d. *By middle Latitude, Plate* 2. *Fig.* VII.

Make the ∠ B C X = 52 22 = the middle latitude, and C X = 450 the difference of longitude, draw X A perpendicular to C B, alſo make B A = 165m. the difference of latitude, join A C which meaſures the diſtance 321 the ∠ C A B 59 degrees the courſe, and C B 275 the departure.

3d. *By* Mercator *per log. For courſe.*

As meridional difference of lat.	270		2.43136
: tangent of radius	45	0	10.
: : difference of longitude	450		2.65321
: tangent of courſe	59	2	10.22185

anſwering to N. W. by W. a quarter W. nearly.

4th. *By table of Natural Sines, Tangents, &c.*

As 270 : 1 : : 450 which contracts to, as 3 : 1 : : 5 : 1.6 the natural tangent of the courſe, againſt which in the table is 59 2 or 5 points and a quarter = N. W. by W. a quarter W.

5th. *By the Traverſe Table.*

In the columns of latitude and departure, find 270 and 450 or rather 27. and 45, againſt which at the bottom is 5 points and a quarter, the anſwer.

6th. *By* GUNTER's *Scale with Compaſſes.*

See the 3d and extend from the 1ſt. term 270 to the 3d. 450, on the line of numbers, that extent ſet on tangent radius 45 degrees, gives 59 2 the courſe as above.

Or by the 4th. on the line of numbers only.

7th. *By Sliding* GUNTER *as before directed.*

8th. *By Logarithm Tangents, for courſe.*

		Log. Tangent
Half the comp. of one lat. 51° is	19 30	9.54914
D° of latitude 53 45 is	18 7	9.51518
Difference		.03396
		Co. Ar.
Then as .03396 × 10000 =	339.6 log.	7.46805
: difference of longitude	550	2.65321
: : the con. factor	51 38 tan.	10.10151
: tangent of courſe	59 2	10.22307

9th. *By Middle Latitude, for courſe, per Logarithms.*

As difference of latitude	165m. Co Ar.	7.78252
: difference of longitude	450	2.65321
: : co. ſine of middle lat.	52 22	9.78576
: tangent of courſe	59 2	10.22159

10th. *To work this proportion per* GUNTER.

Count the middle latitude backwards on the line of ſines, or take its compliment on the ſines, againſt which on the tangents is 31 25; then extend from the firſt term 165 to the 2d. term 450, and that extent reaches from tangent 31 25 to tangent of courſe 59 2 as before.

Then, having found courſe, by the method beſt approved;

diſtance and departure may be found by caſe 2d. of plain ſailing.

Or departure and diſtance may be found independent of the courſe.

1ſt. *By* MERCATOR *for Departure.*

		Co. Ar.
As meridional difference of latitude A x	270	7.56864
: Difference of longitude x z - -	450	2.65321
: : Difference of latitude A B - -	165	2.21748
: Departure B C - - - - -	275	2.43933

2d. *By Middle Latitude.*

As Radius - - -	90 00	10.
: Difference of longitude -	450 m.	2.65321
: : S. Compliment of middle latitude	52 22	9.78576
: Departure - -	275 m.	2.43897

3d. *By Arithmetic only.*

As 270 : 450 : : 165 : 275. Anſwer.

4d. *By natural Sines.*

Compliment of middle latitude is 37 38 the natural ſine thereof is .61 ∵ 450 × .61 = 275. Anſwer.

4th. GUNTER'*s Scale with Compaſſes.*

Extend from the firſt term 270 to the third term 165 on the line of numbers, and that extent reaches from the ſecond term 450 the ſame way, to 275 the departure on that line; or extend from radius 90 to ſine compliment of middle latitude 37 38, and that extent ſet on difference of longitude 450 on the line of numbers, reaches to 275 the departure; or extend from 1 to natural ſine of the compliment of middle latitude .61 on the line of numbers, and that extent ſet on 450, reaches to 275 the departure.

6th. *By ſliding* GUNTER.

See the firſt hereof for departure, ſet 270 on the ſlider, to

165 on the rule, then againſt 450 on the ſlider, ſtands 275 on the rule, the deparure.

7th. By the Traverſe Table.

The compliment of middle latitude 37 28 falls between $3\frac{1}{4}$ and 3^{1} points, therefore in the table find 45 a tenth of the difference of longitude in diſtance column under $3\frac{1}{4}$ ſtands 26.8, and under $3\frac{1}{2}$ ſtands 28.5, whence each multiplied 10, the difference of their products is 17 which reſerve, then $3\frac{1}{4}$ = 36 34 and $3\frac{1}{2}$ = 39 22, the difference of the points is a quarter point, and the difference of the correſponding degrees 2 48 = 2.8 nearly.

And $\overline{37\ 38} - \overline{36\ 34} = 1.04 = 1$ nearly.

Whence 2.82.8 : 17 : : 1 : 6.4 which added to 268 = 274.4 the departure nearly.

Having found courſe and departure, diſtance may be found by Caſe third of plain ſailing.

Or thus, having difference of latitude and departure,

$\sqrt{\overline{275 \times 275} + \overline{165 \times 165}} = 320.7$ the diſtance.

CASE 2d. Both latitudes and courſe given; to find the diſtance, departure, and difference of longitude.

Admit our courſe from a port A in latitude 51 0. N. longitude 1 00 Weſt be N. W. by W. a quarter W. to B in latitude 53 45 N. Query the longitude of B, with diſtance ſailed, and departure.

Peparative to Solution.

Latitude	53 45	Mer. Parts	3839
Ditto	51 00		3569
Diff. lat. 165 =	2 45	Mer. diff. lat.	270

8 30 — 1 0 = 7 30 = 450 difference of longitude.

53 45 + 51 00 = 104 45 ſum of the latitudes.
Half ſum 52 22 the middle latitude.

And 90 00 — 52 22 = 37 38 the comp. middle lat.

1ſt.

1ſt. *Geometrically, by* MERCATOR's *method.*

Pl. 2. *Fig.* VII.

Draw the meridian A x = 270 miles the meridional difference of latitude, raiſe $x z$ perpendicular to A x, and make the $\angle\, x$ A z = 5 points and a quarter = 59 4 the courſe, alſo ſet 165 the difference of latitude from A to B, and draw B C parallel to $x z$, ſo is A C the diſtance 321 miles nearly, meaſured on the ſcale $a x$ was taken from, B C the departure 275 miles, and $x z$ the difference of longitude 450 miles.

Or thus, by middle Latitude.

Draw the meridian A B = 165 the difference of latitude, and B C perpendicular to it; then make the $\angle$ B A C = 5 points, and a quarter the courſe; alſo make the $\angle$B C X = 52 22 the middle latitude, and C X is the difference of longitude = 450 miles.

2*d. By Logarithms.*

For diſtance and departure, ſee Caſe ſecond of plain ſailing.

1ſt. *To find difference of Longitude, by* MERCATOR.

As radius or tangent	45 00	10.
: meridional diff. of lat.	270	2.43136
: : tangent of courſe	59 4	10.22237
: difference of longitude	450	2.65373

2*d. By middle latitude.*

As ſine comp. middle lat.	37 38	9.78576
: tangent of courſe	59 4	10.22237
: : difference of latitude	165	2.21748
Sum of 2d. and 3d. logs		12.43985
: difference of longitude	450	2.65409

by ſubtracting the firſt from the ſum.

3d. *By the Logarithm tangents. A general Rule.*

Take the difference of the logarithm tangents, anſwering to half the compliments of the two latitudes, which difference multiply by 10000, and reſerve that product. Then,

As the con. log. tangent of 51 38 : the reſerved product :: tangent of courſe : difference of longitude.

One lat.	51°	half its comp.	19 30	log. tan.	9.54914
D°	53 45	D°	18 7	D°	9.51518
					.03396

Then .03396 × 10000 = 339.6 the reſerved product.

Whence as the con. log. tangent of	51 38	10.10151
: the reſerved product	339.6	2.53195
:: tangent of courſe	59 4	10.22237
: difference of longitude	450	2.65261

Here the ſecond and third logs. are added, and the firſt ſubtracted from that ſum.

4th. *By the table of natural Tangents, &c.*

Natural tang. of 5 points and a quarter =	1.6
Which multiply by	270 mer. diff. lat.
Product	450 the diff. of lon.

5th. *By natural Sines, Tangents, &c.*

Natural ſine of comp. middle latitude 37 38 = .61

∴ As .61 : 165 :: 1.6 : 450 as before.

6th. *By* GUNTER's *Scale and ſliding Rule, as has been before directed.*

Then for Longitude of B.

To the longitude of A		=	1 0 weſt
Add the difference of longitude	450	=	7 30 weſt
Longitude of B	-	=	8 30 weſt

CASE 3d. Both latitudes and departure given; to find courſe, diſtance, and difference of longitude.

Admit A in latitude 51 00 north, and a ſhip ſails thence north weſterly to B in latitude 53 45 north, the departure being 275 m. required the courſe, diſtance, and difference of longitude?

Sol. Here the difference of latitude is 2 45 = 165 miles, meridional difference of latitude 270m. middle latitude 52 22 compliment of middle latitude 37 38.

1*ſt. Geometrically*; 1*ſt. by* MERCATOR *Fig.* VII.

Draw A B = 165m. and A x = 270m. make B C = 275m. perpendicular to A B, join C A which produce, alſo make x z parallel to B C, whence ∠ B A C is courſe 5 points and a quarter, A C diſtance 321m. x z the difference of longitude 450.

2*d. By middle Latitude.*

Draw A B = 165m. and B C at right angles = 270; join C A, and make the ∠ B C X = 52 22, then draw C X to meet A B produced in X, whence C X is the difference of longitude = 450 miles, ∠ B A C, and A C as before.

2*d. For Courſe, and Diſtance, ſee Caſe the 6th. of Plain Sailing.*

2*d. Logarithmically.* 1*ſt. by* MERCATOR.

		Co. Ar.
As difference of lat. A B	165m.	7.78252
: departure B C	275	2.43933
: : meridional diff. of lat.	270	2.43136
: difference of lon. x z	450	2.65321

2*d.* By *middle Latitude.*

As ſine comp. middle lat.	37 38	9.78576
: departure B C	275m.	2.49733
: : radius or ſine	90 00	10.
: difference of lon. C X	450m.	2.65357

3*d. By Logarithm Tangents ſee the* 3*d. of the laſt Caſe.*

4*th. By natural Sines, Arithmetically.*

As .61 : 275 : : 1 : 450 the difference of longitude.
Or as 165 : 270 : : 275 : 450 as before.

5*th.*

5th. By GUNTER's *Scale with Compaſſes.*

In all the preceeding proportions in this caſe

Extend from the firſt term to the third on the ſame line, that extent ſet on the ſecond term, falls on the fourth or anſwer.

6th. By Sliding GUNTER.

Set the firſt term on the ſlider, to the third term on the rule of the ſame name; then againſt the ſecond term on the ſlider, ſtands the fourth or anſwer on the rule.

CASE 4th. One latitude courſe and diſtance given; to find the difference of longitude.

Admit a ſhip ſails from A in latitude 51 0 North, N. W. by W. half W. 321 miles to B, required its latitude and difference of longitude?

1ſt. *Geometrically Pl.* 2. *Fig.* VII.

Draw the meridian A B, at A make the ∠ B A C = 5 points and a quarter the courſe, and A C = 321 miles the diſtance, then let fall the perpendicular B C from C, and A B meaſures 165 = 2 45 which added to 51 makes 53 45 then, the extent from 51 to 53 45 on Mercator's meridian line, meaſured on the contiguous line of longitude or equal parts is 4 30 = 270 the meridional difference of latitude, which ſet from A to *x*, draw *x z* parallel to B C, for the difference of longitude which meaſures 450 miles.

2d. *By middle Latitude.*

Having found the other latitude as above, make the ∠ X C B = the middle latitude 52 21, produce A B to meet C X in X, and C X meaſures 450 miles the difference of longitude.

Solution. Find the departure B C, and difference of latitude A B, by Caſe 1ſt. of plain ſailing.

2d. *By Mercator and middle Latitude, for difference of Longitude, by Logarithms.*

To latitude A	-	51 0 N.	meridional parts	3569
diff. lat. by Caſe 1ſt. of Plain ſailing 165	=	2 25 N. Add		
Latitude of B	-	53 45	mer. parts	3839
Sum ÷ -	2)	804 45	mer. diff. of lat.	270
Middle lat.		52 22	compliment D°.	37 38

1ſt. *By* MERCATOR, *and Logarithms.*

		Co. Ar.
As ſine compliment courſe	30 56	0.28901
: meridional diff. of lat.	270	2.43136
: : ſine of courſe	59 4	9.93336
: differene of longitude	450	2.65373

2*d. By middle Latitude, and Logarithms.*

As ſine comp. of middle lat.	37 38	9.78576
: departure	275	2.43933
: : radius or ſine	90 00	10.
: difference of longitude	450	2.65357

3*d. By natural Sines, for difference of Longitude, as* MERCATOR.

5 points and a quarter = 59 4 its nat. ſine .85
2 points and three quarters = 30 56 ditto .51
∵ As .51 : 270 : : .85 : 450 anſwer.

As middle Latitude, ſee the laſt caſe of this.

4*th. By Scale and Compaſſes, for difference of Longitude.*

As ſine co. of co. $2\frac{3}{4}$ points : 270 : : ſine of co. $5\frac{1}{4}$: 450. Extend from ſine 2 and three quarters, to ſine 5 points and a quarter, and that extent ſet on 270 on the line of num. falls on 450 miles the difference of longitude.

5*th. By ſliding* GUNTER, *For difference of Longitude, ſee the* 3*d. hereof.*

Set .51 on the ſlider, to .85 on the rule, then againſt 270 on the ſlider, ſtands 450 on the rule the anſwer.

Scholium.

When one latitude, courſe, and departure, or one latitude, diſtance, and departure are given; the difference of latitude muſt be found by Caſe 3d. or 4th. of plain ſailing, and then the other latitude, before the difference of longitude can be found.

Case 5th. One latitude, courſe and difference of longitude given; to find the other latitude, diſtance, and departure.

Admit a ſhip ſails from A in latitude 51 0 north, longitude 1 0 weſt, N. W. by W. a quarter W. to B whoſe longitude is known 8 30 weſt, required the latitude of B, with diſtance ſailed, and departure.

Sol. $\overline{8\ 30} - \overline{1\ 0} = 7\ 30 = 450$ the diff. of longitude

1ſt. Geometrically. Plate 2, Fig. VII.

Draw $x z = 450$ the difference of longitude, make A x perpendicular to $x z$, alſo make the $\angle x z$ A = 2 points and three quarters the comp. of the courſe, then A x meaſures 270 the meridional difference of latitude, which added to the meridional parts of 51 degrees (viz) $270 + 3569 = 3839$ the meridional parts anſwering to 53 45 the other latitude.

Then ſet 165m. = 2.45 the difference of latitude from A to B, and draw B C parallel to $x z$, whence B C is departure, and A C the diſtance.

2d. Mercator's *method, by Logarithms for meridional difference of Latitude.*

As tangent of courſe	59 4	10.22237
: difference of longitude $x z$	450	2.65321
: : tangent radius	45 0	10.
: meridional difference of lat.	270	2.43084

Or as ſine courſe 5 points and a quarter	59 4	0.06664
: difference of longitude	450	2.65321
: : ſine co. of co 2 points and three quarter	30 56	9.71099
: meridional difference of latitude	270	2.43084

Then, to meridional parts of lat. A	51.0 =	3569
Add the meridional diff. of lat.		270
Sum is the meridional parts of lat. B	53 45	3869

Difference of latitude 2 45 = 165 m.

Whence diſtance and departure may be found per caſe 2d. of plain ſailing.

N. B. If the meridional difference of latitude come out greater then the meridional parts of the given latitude, ſubtract the latter from the former, and the remainder is the meridional parts anſwering to the latitude ſhip, on the contrary ſide of the line, for the ſhip has croſſed the line, during the time of ſailing from A to B.

3d. *By middle Latitude and Logarithms,* Work with the given Latitude as under.

As tangent of courſe	59 4	10.22237
: difference of longitude	450	2.65321
: : co. ſine of given latitude	51 0	9.79887
: a difference of latitude	169	2.22971

Then to the given lat. of A 51 00 m.
Add difference of lat. becauſe N. 2 49 = 169

Which added to the former 53 49
Sum divided 2)104 49

Is middle latitude 52 24

Then as tangent courſe	59 4	10.22237
: difference of longitude	450	2.65321
: : ſide comp. of middle lat.	52 24	9.78544
: difference of lat.	165m.	2.21627

∵ Lat. A 51 00 + 2 45 = 53 45 latitude B.

4th. *By Logarithm Tangents.*

As tangent of courſe	59 4	10.22237
: difference of longitude	450	2.65321
: : tangent of conſt. factor	51 38	10.10147
: A fourth term	341	2.53231

Then from tan. of half comp. of the given lat. } 19 30 .654914
Subtract 341 ÷ by 10000 = 0341

Tangent 18 7 and a half 9.51504

∵ 18 7 and a half, doubled is 36 15, and its compliment 53 45 is the latitude B, whence the difference of latitude is 2 45 = 165 miles.

5th. By GUNTER's *Scale.*

The extent from tangent of courſe 59 4, to tangent 45, will reach from the difference of longitude 7 degrees and a half, to 4 degrees and a half, the meridional difference of latitude on the line of numbers; then take 4 30 from the line E P, and ſet them on the meridional line, from the latitude left 51 deg. increaſing (becauſe the courſe is northerly) and it reaches to 53 45 the latitude of B required.

6th. By the Traverſe Table.

Over 5 points and a quarter, and in column departure find difference of longitude 450, or rather 45 a 10th. thereof, in the adjoining column over latitude is 27, which × 10 = 270 the meridional difference of latitude, which added to the meridional parts of 51 degrees (viz) 3569 makes 3839 anſwering to latitude 53 45 in the table, the latitude of B required.

The THEORY *of the* SUN's *Declination.*

1ſt. The apparent annual path of the ſun in projections of the ſphere, or on the celeſtial globe called the ecliptic, makes an angle with the equinoctial of 23 deg. 29 min.

2d. This 23 29 is the ſun's greateſt declination north or ſouth, was firſt obſerved, as report hath it, by PYTHEAS at *Maſtilia* about 324 years before CHRIST; and GASSENDUS concluded it was the ſame about the year 1680 ſince CHRIST, and at the preſent time, there is no great reaſon to believe it much altered.

3d. The ſun's declination, is always its apparent diſtance, from the equator, reckoned in degrees and minutes.

4th. The ſun is in the equinox without declination on March the 21ſt. and thence to June the 21ſt, it is north increaſing, then north decreaſing to September 22d. at which time it croſſes the equator, and becomes ſouth increaſing till December 21ſt. then to March the 21ſt. it is ſouth decreaſing. [See the introduction page 17 and 18.]

PROBLEM, Having the ſun's declination and his meridian altitude, or its compliment, called his zenith diſtance given; to find the latitude or.

To

To work an Obſervation.

Among the various inſtruments, that have been contrived, and adapted by artiſts for obtaining the meridian altitude of the ſun or of a ſtar, that curious, and uſeful quadrant, or rather Octant, called HADLEY's Quadrant ſtands beſt recommended, for general utility; by which the latitude can be found at ſea to the greateſt certainty, if the ſun can be ſeen on the meridian.

Therefore it may be premiſed, that the elevation of the pole is equal to the zenith diſtance of the equinox, or compliment of its meridian altitude, and alſo equal to the latitude of the place, whence it follows, that when the ſun is in the equinox, his zenith diſtance upon the meridian, of any place, is the latitude of that place.

CASE 1ſt. If the ſun or a ſtar be obſerved ſouthward, with ſouth declination; or northward, with north declination; the equinox will be between the zenith and the obſerved object. Therefore, ſubtract the declination from the zenith diſtance, and the difference is the latitude, contrary to the declination with reſpect to north or ſouth. See P. 2. F. VIII.

If the ſun's zenith diſtance be obſerved 51 40 ſouthward on the 10th. of December when the declination is 23 6 ſouth; required the latitude?

1ſt SOLUTION. *Geometrically by Projection.*

Draw H H the horizon, on which deſcribe a ſemicircle with the chord of 60 degrees, make S Z perpendicular to H H at the centre, then ſet the chord of the obſerved zenith diſtance, from Z to the right hand if ſouthward, but to the left if northward to ☉, alſo ſet the chord of the ſun's or ſtar's declination from ☉ towards Z to Æ the equinox; laſt ſet a quarter of your circle or ſine 90, from Æ to the left hand, when the object obſerved is ſouthward, and the contrary when northward to P the pole, and H P meaſured on the ſcale of chords is 28 34 the latitude north, which was required.

2d. By the Pen.

From the ſun's Zenith diſtance	51	40	S.
Subtract the ſun's declination	23	6	S.
Remains Z Æ = H P the latitude	28	34	N.

Caſe 2d. If the ſun or a ſtar be obſerved on the meridian ſouthward, with north declination or northward with ſouth declination; the object obſerved will be between the equinox and zenith. Therefore add the declination to the zenith diſtance, and that ſum is the latitude of the ſame name as the declination North or South.

If the ſun's zenith diſtance be obſerved 34 18 ſouthward on May the 31ſt. when the declination is 22 3 N. required the latitude?

1ſt. Geometrically by Projection. Pl. 2 *Fig.* IX.

Draw the ſemicircle, and ſet off the zenith diſtance as directed in caſe 1ſt. then ſet the chord of the declination from ☉ towards H. to Æ. and draw SÆ, alſo P S perpendicular thereto, whence P H, meaſured on the chords is 56 21 the latitude north.

2d. by the Pen.

To the ſun's zenith diſtance =	34 18 S.
add his declination - - -	22 3 N.
Sum Z Æ = H P the latitude	56 21 N.

Case 3d If the ſun or a ſtar be obſerved on the meridian northward or ſouthward, when the declination of the object exceeds the zenith diſtance, the zenith will then be between the object and equinoctial. Then the zenith diſtance obſerved, ſubtracted from the declination, gives the latitude of the ſame name as the declination.

If the ſun's zenith diſtance be obſerved 11 40 to the northward on the 20th of June, when its declination is 23 29 N. required the latitude of the obſerver?

1ſt. Geometrically by Projection, Pl. 2 *Fig.* X.

Draw the ſemicircle, on the horizon H H, and S Z perpendicular thereto, alſo ſet the zenith diſtance as directed in caſe 1ſt. Then ſet the chord of the declination from ☉ paſt the zenith Z, to Æ, draw S Æ, and P S perpendicular thereto, ſo ſhall H P meaſure the latitude 11 49 N.

2d. *By the Pen.*

From the ſun's declination - - 23 29 N.
Subtract zenith diſtance - - 11 40 N.

Difference is Æ Z = H P the latitude - - 11 49 N.

Case 4th. If the ſun's or a ſtar's meridian altitude be obſerved under the pole, then will the object obſerved be between the elevated pole and the horizon. Therefore add the compliment of the declination, to the obſerved altitude, and the ſum is the latitude north, or ſouth, agreeing with the declination.

If the ſun's altitude be obſerved 8 24 northward under the pole on July the 10th. when the ſun's declination is 22 12 N. required the latitude of the obſerver?

1ſt. *Geometrically; by Projection. Pl.* 2 *Fig.* XI.

On H H deſcribe a ſemicircle as before directed, alſo make Z S perpendicular to H H, at S the centre, then ſet the chord of the altitude on the left ſide from H to ☉ becauſe it was obſerved northward, alſo ſet the chord of the declination from ☉ downwards to Æ, draw Æ S and P S perpendicular thereto, and H P meaſures the latitude 76 12 northward, on the chords. W. W. R.

N. B. In all the preceding directions for projection, If P the pole comes above the horizon on the left ſide of ZS, the latitude is north; but if P ſhould be above the horizon to the right ſide of Z S, the latitude then is ſouth.

2d. *By the Pen.*

From a quarter of the circle - - 90 00
Subtract the ſun's declination - 22 12 N.

Compliment of the declination = - - 67 48
To which add the ſun's altitude - - 8 24

Sum is the latitude H P - - 76 12 N.

To obſerve the ſun's meridian altitude with great accuracy.

1ſt. The height of the eye of the obſerver above the ſurface of the ſea, makes the obſerved altitude a little too great, ſee Introduction page 19.

2d. According as you obſerve by the ſun's upper or under limb, you muſt ſubtract or add 16 minutes to the obſerved altitude.

3d. Another correction of the obſerved altitude, ariſes by reaſon of refraction, ſee Introduction pages 19 and 20.

4th. The ſun's declination muſt be corrected, when you are in remote longitudes from the meridian of your tables, ſee the Introduction pages 17 and 18.

5th. If you have not tables of the ſun's declination you muſt find it as directed in pages 17 and 18 of the Introduction.

Example. Admit the ſun's meridian altitude be obſerved on board a ſhip 30 feet above the water, by its under limb, to the ſouthwward 37 48 m. on the 27th. of November 1773 required the latitude obſerved in?

To Correct the Altitude.

	D.	M.
Altitude obſerved	37	48
For the height of the eye 30 feet ſubtract		7 m.
	37	41
For the obſerved under limb add		16 m.
	37	57
For refraction ſubtract		1 m.
True altitude	37	56
Subtract from	90	00
Sun's zenith diſtance	52	4
By caſe 1ſt. ſubtract ſun's declination	21	17
Latitude required	30	47 N.

Again if the ſun's meridian altitude be obſerved ſouthward on the 24th. of October 1773, 18 9 by its upper limb on board of a ſhip 42 feet above the water, in 165d. 27m. weſt longitude, required the declination corrected, and latitude obſerved in.

1ſt. To correct the declination for longitude 165 27 weſt
ſee the Introduction, page 18.
By our tables October 24th. ſun's declination 11 57 ſouth
Do. 25 Do. 12 18 ſouth

The daily difference then 21m.

∵ As 360 : 21 : : 165.5 : or by contraction,
As 8 : 7 : : 11 : 9 min. the proportional part, to be added to the ſun's declination that day by the tables.

∵ 11 57 + 9 = 12 6 the ſun's declination that day in longitude. 165 27 weſt
Whence from the ſun's obſerved altitude 18 9 ſouth
Subtract for the height of the eye 8
17 1
Sun's ſemidiameter ſubtract for the upper limb 16m.
17 45
Refraction for altitude 18 9 ſubtract 3

Sun's altitude corrected 18 42
Which ſubtract from 90 00

Gives ſun's zenith diſtance 72 18
Sun's declination corrected ſubt. 12 6 ſouth

The latitude obſerved in 60 12 north

VARIATION of the COMPASS.

THE imperfection of the magnetical compaſs, opens a large field for the invention of ways and means, for the diſcovery thereof, both in quantity, and quality, that is, how much it deviates from the true north, and whether to the eaſt or weſt thereof, ſee the Introduction pages 21, 22, 23.

PROBLEM. The latitude of a place, ſun's declination, or day of the month, and the magnetical amplitude of the ſun at riſing or ſetting given; to find the variation of the compaſs in quantity and quality.

EXAMPLE. Admit the lattitude 52 10 north
Sun's declination 18 40 north
Magnetical amplitude in the morning 12 15 ſouth } given;
Required the variation in quantity and quality?

1ſt. *Sol. Geometrically, Pl.* 2. *Fig.* XII.

1ſt. Draw a circle with a ſweep of 60 deg. and quarter it as per fig. with N. S. E. and W. but W. at top, and N. at the right hand.

2d. Set the chord of the latitude if north, from N upwards to P, alſo from W to Æ if the latitude had been ſouth, that chord muſt have been ſet from S. upwards to I, and from W. to Æ. then draw the axis P I, and equinox Æ Q.

3d. Set the chord of the declination if north from Æ and Q towards N. but if ſouth towards S. and draw the parallel of declination *a b*, to cut the horizon N S in *c*, the place of ſun riſing, or ſetting.

4th. Draw C F, parallel to W E. downwards if morning, but upwards if evening, ſo is E F or W F the true amplitude from eaſt or weſt, meaſured on the ſcale of chords.

5th. Set the chord of the magnetical amplitude from E if morning, or from W if evening, towards N or S according as it is north or ſouth to G.

6th. Extend on the ſig. from G to N which ſet from F, and the other foot falls on *n*, and the arch N *n* is the variation weſt, when *n* falls between N and W but eaſt, when *n* falls between N and E. and this arch of the variation in quantity is meaſurable on the ſcale of chords = 43 deg. and a half weſt.

2*d. By Calculation, ſee Introduction. Page.* 21.

1ſt. To find the true Amplitude of the Sun at Riſing, or Setting.

As ſine compliment of latitude -	37	50	9.7877
: Radius or ſine - - -	90	00	10.0000
: : Sine of the ſun's declination -	18	40	9.5052
: Sine of true amplitude N ° - -	31	27	9.7175

2d. To reckon both Amplitudes from the North.

D. M. D. D. M. D. M.
Mag. amp. 12 10 E. S. or 90+12 15=102 15 = N G.
True amp. 31 27 E. N. or 90—31 27= 58 33 = N F.

Per Introduction page 22 the variation is 43 42 weſt

If the ſun riſe to the northward of eaſt, or ſet to the northward of weſt, the compliment of the amplitude is its diſtance from north, but if it riſe to the ſouthward of eaſt, or ſet to the ſouthward of weſt, add 90 deg. to the amplitude, for its diſtance from north.

3d. Having reckoned both the true and magnetical Amplitudes from North in degrees or points. Obſerve this ſhort general rule.

Turn your face to the riſing or ſetting ſun, then if the true amplitude be to the right hand of the magnetical, the variation is eaſterly, But if to the left it is weſterly; and their difference is the variation.

N. B. This rule is equally true for an azimuth.

3d. By an azimuth Compaſs, when the Sun is on the Meridian.

Obſerve carefully what point or degree the ſun is on at mid day, that is, juſt when you have the beſt altitude on your quadrant, and the degrees on the compaſs, between the ſouth and that point the ſun is on is the variation weſt, if the ſun be to the weſtward of the magnetical meridian; but eaſt, if the ſun be to the eaſtward thereof.

In the preceeding example, the ſun on the meridian that day would be 43 degrees $\frac{1}{2}$ or 3 $\frac{3}{4}$ points, to the weſtward of the magnetical meridian anſwering to the variation W. as found before.

4th. *By two equal Altitudes of the Sun in the Morning and Evening, with their correſponding Azimuths.*

Take with your quadrant the ſun's altitude, in the morning as ſoon as convenient, and let an aſſiſtant at the ſame time note down the ſun's azimuth, or point of bearing from the ſouth, in points and quarters, or in degrees and minutes. Alſo in the afternoon obſerve with your quadrant, when the ſun is the ſame height; your aſſiſtant, again noting down the ſun's azimuth from the ſouth. Then as it is evident the ſun at mid-day was on the middle point between the morning and evening azimuths of the ſame altitude, the diſtance of that point from ſouth is the variation, weſt, if the ſaid middle point be in the S. W. quarter; but eaſt, when that middle point is in the S. E. quarter.

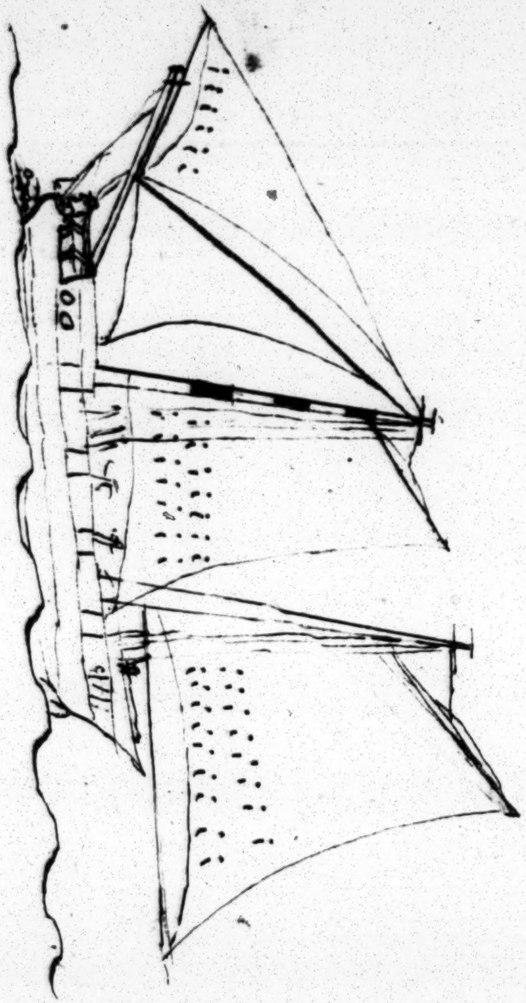
Admit the ſun had been obſerved in the morning at a certain height S. E. by E. $\frac{3}{4}$ E. and in the evening at the ſame height his azimuth was found N. W. by N. three quarters W. required the variation in quantity and quality.

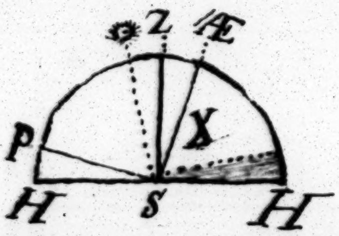
Sol. 1ſt. Azimuth in the morning S. E. by E. $\frac{3}{4}$ E. = } 5 $\frac{3}{4}$ points
2d. Ditto Evening N. W. by N. $\frac{3}{4}$ W. = 12 $\frac{1}{4}$ from ſo.
2)18 0 Sum.
Half ſum 9
Sub. 5 $\frac{3}{4}$
Variation Weſt 3 $\frac{1}{4}$.

In this example the ſun at mid day bore 9 points from the firſt azimuth, which makes 3 and a quarter from the ſouth weſterly, the variation.

5th. by the ſun's true and magnetical amplitudes, at riſing or ſetting by the plain ſcale, ſee Plate 2, Fig. XIII.

Deſcribe the circle S W N E with the chord 60 for the horizon, let N. the north; E. the eaſt points &c. let the chord





Z
Æ
X
P
H
S
H

Plate 2

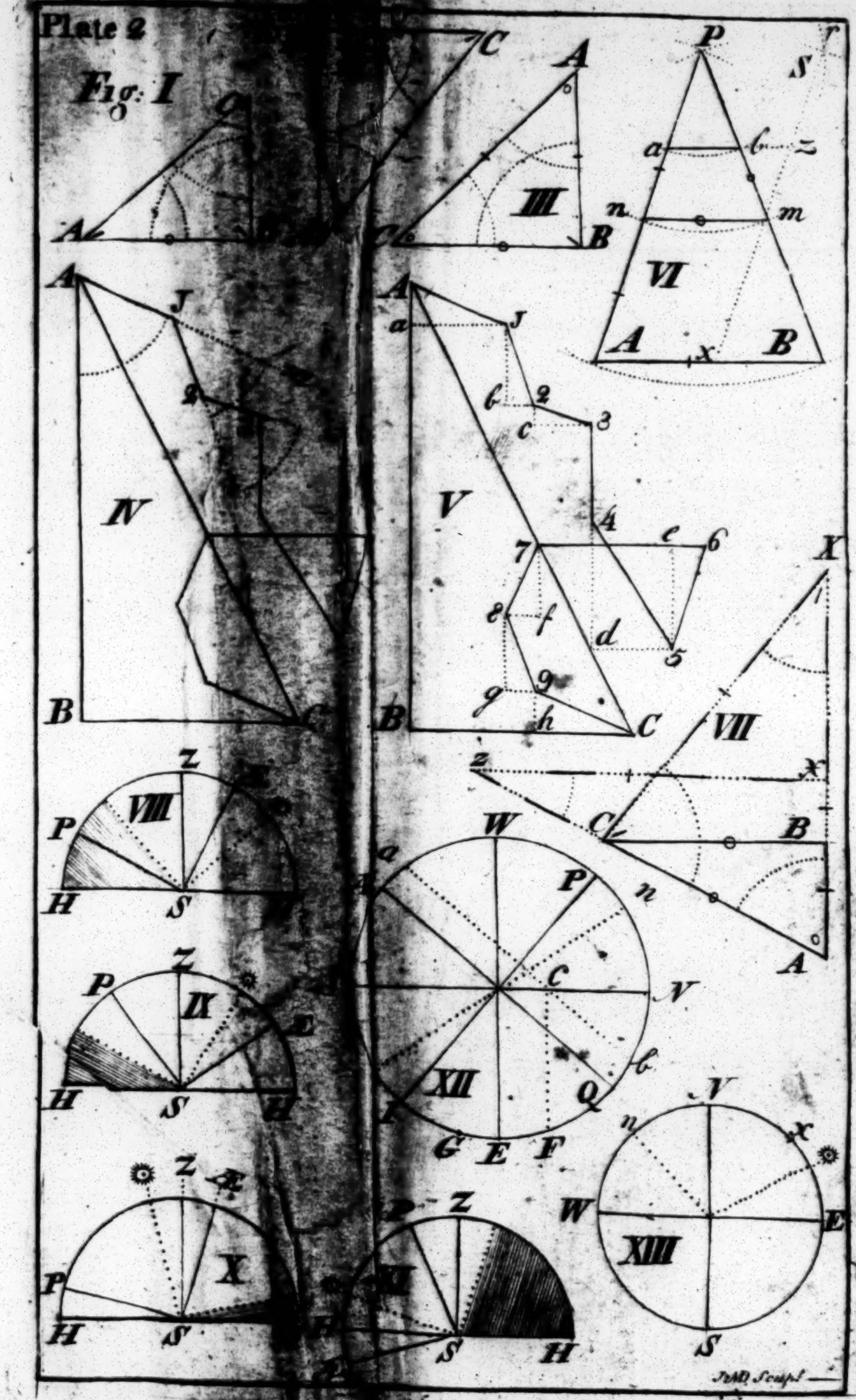


Fig: I
C
A
B
III
P
S
a
b
z
n
m
VI
A
x
B
J
2
IV
V
3
c
4
e
6
7
8
f
d
5
9
g
h
X
VII
z
x
C
B
VIII
Z
P
H
S
W
P
n
IX
E
V
b
XII
Q
G
E
F
Z
X
XI
W
XIII
E
S

chord of the ſun's true amplitude at riſing, from E. towards N. or S. according as the ſun's declination is north, or ſouth; but at ſun ſetting, ſet it from W. with the ſame caution to ☼ Then ſet the magnetical amplitude from ☼ towards S. if it be northerly as to *x*; But you muſt ſet it towards N. if it be ſoutherly; make *x n* = N. E. = 90 degrees and *n* N. is the variation weſt, when *n* falls between N. and W. but eaſt when it falls between N. and E. as in the preceeding example where the true amplitude is 31 27 N. and the magnetical amplitude 12 15 S. in the morning.

Therefore having drawn the circle as before directed, ſet the true amplitude (becauſe northerly) 31 27 from the ſcale of chords, from E. towards N. to ☼ alſo ſet the chord of the magnetical amplitude (becauſe ſoutherly) from ☼ towards N to *x*, Then 90 degrees from the ſcale of chords ſet from *x* to *n* gives the variation *n* N. = *x* E. = 43 degrees and a half weſt, meaſured on the ſcale of chords.

SCHOLIUM. It is now certainly known that the variation of the compaſs is always altering, at London 200 years ago it was one point or 11 degrees and a quarter eaſtward, decreaſing at a ſlow rate about 9 or 10 minutes a year, ſo that in the year 1657 there was no variation, again about 50 years ago the variation was 1 point, increaſing by a ſlow motion weſtward ſo that now in 1773 it is above 18 degrees yet increaſing, but in ſome places it moves eaſtward, in others it ſeems to be at a ſtand, and the increaſe or decreaſe is variable in different places, and alſo in the ſame place at different times, whence it appears probable that in a few years the variation will be a maximum weſterly.

A TABLE of the VARIATION of the Compaſs,

As has been obſerved in ſeveral places; but is not much to be depended on, as it is in moſt places uncertain, and in many places unknown, beſides the variation is always altering, ſo that it ſhould be obſerved for, at all opportunities.

COAST OF ENGLAND,

	Deg.
London	10 W.
On the Weſt at Sea	13 W.
Britiſh Channel	16 W.

COAST OF EUROPE.

	Deg.
Baltic	12 W.
Weſt Coaſt of France	12 W.
Weſt at Sea	11 W.
German Ocean	14 W.
Portugal Coaſt	10 W.
Straits of Gibralter	7 W.
Majorca Iſland	16 W.
Sardinia	13 W.
Sicily	12 W.
Canary Iſlands	7 W.
Azores Iſlands	8 W.

COAST OF AFRICA.

Barbary N. W. Coaſt	8 W.
—— N. E. Coaſt	6 W.
Guinea S. Coaſt	5 W.
Madagaſcar Weſt Coaſt	19 W.
—— To the Southward	25 W.
St. Helena	2 W.
Cape of Good Hope	16 W.

COAST OF ASIA AND EAST INDIES.

Bombay	8 W.
Cape Comerin	5 W.
Java Coaſt	2 W.
Indian Sea	15 W.
Maldivia Iſlands	10 W.
Malacco	3 E.
New Guinea Coaſt	6 E.
—— Holland	4 W.
—— Zealand	9 E.
Van Demiens Land	1 E.

COAST OF AMERICA NORTH AND SOUTH.

Virginia	6 W.
Hudſon's Bay	30 W.
—— Straits	40 W.
Newfoundland Coaſt	20 W.
—— England	10 W.
River Plate before	19 E.

Straits

Straits Magellan Eaſt Entry ———	15	E.
——— Weſt Entrance ———	13	E.
Terra Magellanica E. Coaſt ———	19	E.
Cape Frio ——— ———	12	E.
Baffins Bay ——— ———	57	W.
Braſil Coaſt, Latitude 10 S. ———	6	E.
——— Ditto 20 S. ———	12	E.
Chili, Weſt Coaſt ——— ———	8	E.
Triſtian de Cunha Iſlands ———	0	

To Work a Day's Reckoning at Sea.

A Day's reckoning or day's work, conſiſts of an exact account of all courſes, and diſtances that a ſhip ſails in 24 hours viz. from 12 o'clock or noon till 12 o'clock or noon the next day, when out of ſight of land; and to perform this, the aſſiſtance of traverſe ſailing is called in, when the ſhip ſails different courſes in 24 hours, therefore the man at the helm muſt keep cloſe to the appointed courſe, or otherwiſe obſerve carefully what courſe he ſteers; alſo once in two hours the log is to be heaved, and the knots and quarters or tenths, run off in half a minute, muſt be fairly entered on the log board, or in the log book againſt the hour: thus are all courſes and diſtances, every two hours to be written down, againſt their reſpective hours, as in the following table repreſenting the log board or log book.

Hours.	Courſes.	Knots.	Winds.	Tranſactions
2	— —	—	—	At 6 P. M.
4	— —	—	—	Cape Clear
6	W. S. W.	7	S. E.	bore N. E
8	—	7½	—	by N. diſt. 9
10	S. W. by W.	8	S. E. by E	miles,
12	— —	8	—	A briſk gale,
2	— —	7	—	ſingle reeft
4	S. W ½	6½	E. S. E.	topſails.
6	— —		—	Sun's mer.
8	—	7	—	alti. 64 27.
10	S. W	7½	—	Var. 2 and
12	— —	7	—	a half pts W.

N. B. The courſes on the log board, muſt be ſet down as given by the compaſs, and 24 hours after or the next day at noon, all the courſes the paſt day are to be carefully corrected, by proper allowances for variation and leeway, and if there be a current, conſider it as a new courſe of the ſhip, all which muſt be put into a new table, and for ſhortneſs put down the diſtances in one ſum that belong to the ſame courſe, doubling each diſtance from the log board as the log is only heaved every two hours.

Whence we get the following TABLE.

Courſes Corrected.	Points	Diſt.	N.	S.	E.	W.
S. $\frac{1}{2}$ W.	$\frac{1}{2}$	9	—	8.8	—	.9
S. W. by S. $\frac{1}{2}$ W.	3 $\frac{1}{2}$	29	—	22.2	—	18.3
S. S. W. $\frac{1}{2}$ W.	2 $\frac{1}{2}$	46	—	40.4	—	21.8
S. S. W.	2.	39	—	38.2	—	7.6
S. by W. $\frac{1}{2}$ W.	1 $\frac{1}{2}$	29	—	27.6	—	8.4
N. B. S. half W. diſt. 9 is the true bearing of the ſhip from the Cape.				137		57

Then having ſet down as above the courſes corrected, points, and diſtances, find the difference of latitude, and departure, by the traverſe table, or otherwiſe as directed in traverſe ſailing, by which the difference of latitude will be found 137 ſoutherly and the departure 57 weſterly. Alſo the courſe made good, and diſtance, may be found by the 6th. caſe of plain ſailing, and the difference of longitude by caſe the 2d. of MERCATOR ſailing, whence the place of the ſhip is known, all which muſt be carefully entered into the journal; and then the day's reckoning is completed.

It will alſo be neceſſary often to calculate, what courſe to ſteer to find your deſired port; by the firſt caſe of MERCATOR, after you have found the latitude and longitude the ſhip is in.

To Correct the Reckoning.

[See the Introduction. Pages 27 28 and 29.]

To keep a Journal of a Ship's way at Sea; Or to keep a Sea Reckoning.

In keeping a journal, chooſe a quarto book, conſiſting of 2, 3 or 4 quires of paper, ruled as directed in page 24 of the introduction, or as in the following journal, into this book, muſt daily be punctualy wrote down, from the log board or log book the courſes, diſtances, difference of latitude, and departure, with latitude and longitude the ſhip is in, tranſactions of the day, as winds, weather, currents, ſetting of the ſea, handing of ſails, ſoundings if any, death of men, meeting or parting with ſhips, ſun's meridian altitude, ſun's true and magnetical amplitudes, the variation of the compaſs with other accidents, or occurences, this book ought to be ruled and prepared before you go to ſea, that it may be ready for uſe.

When you go out to ſea, you muſt find the courſe to be ſteered, by having the true courſe, and variation, this may be done by laying a thread over the figure of the compaſs to repreſent the true meridian, and from this reckon as many points into the proper quarter as your courſe is, and where that falls is the compaſs courſe to be ſteered.

At parting with the ſight of the port, or ſome cape or head land, of a known latitude and longitude, its bearing muſt be obſerved, and diſtance eſtimated, and the opoſite point and eſtimated diſtance may be conſidered as the firſt courſe and diſtance from that cape, then at the end of every two hours, write on the log board the courſe ſteered and diſtance run againſt the hours, and this work muſt be repeated at every two hours of your day's work, and alſo every day..

Then mind, that every day at noon you copy into your journal, what you find on the log board, and work up your day's reckoning as before directed, placing the courſe corrected, diſtance, difference of latitude, departure, latitude, difference of longitude, longitude ſhip, in their reſpective columns, ſee the following example of a journal

N. B. the title of your journal muſt expreſs the latitude and longitude of the place ſailed from, and bound to, with true courſe and diſtance found per caſe 1ſt of mercator's ſailing

We ſhall only add that our young navigator ſhould never omit, to obſerve the ſun's meridian altitude, in order to aſcertain the true latitude, nor ever omit to take the ſun's magnetical amplitude morning or evening, to obtain the true variation, and that we ſhould think him better qualified, for giving a good account of a ſhip's way at ſea, provide he knew a few of the principle fixed ſtars, whoſe declinations are known, ſo that coming in with land in winter when days are ſhort, and ſubject to be thick and hazey, he might obſerve by a ſtar in the night, and thereby obtain his latitude, and be ſure to look out for land ſome days before he expect by his reckoning to be at it.

A Table of the Declination of ſome principal fixed Stars, to the year 1774.

Stars	Declination			Stars	Declination		
	D.	M.			D	M.	
Arcturus	20	22	N	Orion's Belt middle	1	22	S.
Andromeda's head	27	50	N	— Foot Rigel	8	28	S.
Brighteſt of Aries	22	23	N.	— Right Shoulder	7	21	N.
Do. of the 7 Stars	23	23	N	Pegaſus Wing	13	56	N.
Bull's eye Aldebra	16	2	N.	Scorpion's Heart	25	54	S.
Eagle's heart Aquila	8	15	N.	South Fiſh Fomel.	30	55	S.
Great Dog Syrius	16	24	S.	—Twin Polux	28	34	N.
Hydra's heart Alph.	7	40	S	Swan's Tail Deneb.	44	25	N.
Laſt in G. Bear's ta.	50	27	N	The Goat Capella.	45	44	N.
Lion's heart Regu.	13	3	N.	---Harp Lyra	38	35	N.
Ditto Tail	15	50	N	Virgins Spike	9	58	S.
Nor. Cro. Ariadne	27	30	N	Whale's jaw Cetus	3	11	N.
Do. Twin Caſtor	32	22	N.	---South Tail	19	14	S.

A

Journal of a Voyage,

IN THE

WHITEHAVEN;

From *Cape Clear*,

Latitude		51 10 N.
Longitude		10 30 W.

Towards *Cape Henry*,

Latitude		37 00 N.
Longitude		75 2 W.
Courſe	S.	72 53 W.
Diſtance		2888 m.
Departure per MERCATOR's Sailing		2760 m.

A. B. Maſter, kept by X. Z. Mate.

Hours.	Courſes.	Knots.	Half knts	Winds.
2	—	—		—
4	—	—		—
6	W. S. W.	7	½	S. E.
8	—	7		—
10	S. W. by W.	8		S. E. by E.
12	—	8		—
2	— —	7		— —
4	S. W. ½ W.	6	½	E. S. E.
6	—	6		—
8	—	7		—
10	S. W.	7	½	—
12	—	7		—

Courſes.	Courſes Corrected	Points.	Diſt.	S.	W.
S. W. by S.	S ½ W.	½	9	8.8	.9
W. S. W.	S. W. by S. ½ W.	3 ½	29	22.2	8.2
S. W. by W.	S. S. W. ½ W.	2 ½	46	40.4	21.8
S. W. ½ W.	S. S. W.	1 ½	39	38.2	7.6
S. W.	S. by W. ½ W.	1 ½	29	27.6	8.4
				137	57

July 1*ſt*. Courſe made good.	Diſt	N.	S.	E.	W
S. 22 35 W. Or S. S. W.	148	—	137	—	57

TRANSACTIONS.

JUNE 30th. This afternoon at 6 had Cape Clear bearing N. E. by N. diſtance 3 leagues by eſtimation, a fair briſk gale.

At 5 A. M. ſpoke the Favourite of Glaſgow from Virginia, ſingle reeft topſails.

Sun's meridian altitude	-	64 17
makes latitude per obſervation	- -	48 53

Variation 2 points weſt.

Sun's zenith diſtance	- -	25 13 S.
Declination add		23 10 N.
Latitude per obſervation	- -	48 53 N.

Longitude cape	- -	10 30 W.
Difference of longitude add	- -	1 29 W.
Longitude ſhip	- - -	11 59 W.

N. B. In this days work the bearing of the cape at 6 o'clock N. E. by N. is conſidered as the ſhip's courſe from the cape on the opoſite point S. W. by S. diſtance 9 miles which when two and a half points are allowed for variation to the left hand makes S. ½ W. and ſo for the other courſes as above.

Latitude	Departure	Diff. long	Long ſhip
48 53 N.	57	89	11 59 W.

Hours.	Courſes.	Knots.	Winds.
2	S. W.	7.4	E. S. E.
4	—	6.5	S. E.
6	—	6.	—
8	S. W. by W.	6.6	S. E. by S.
10	—	7.	—
12	W. S. W.	7.	S.
2	—	6.4	—
4	Weſt.	5.8	S. S. W.
6	—	5.7	—
8	W. by N.	5.	S. W. by S.
10	—	6.7	
12	W. N. W.	6.6	S. W.

Courſes corrected	Points.	Diſt.	N.	S.	E.	W.
S. by W. $\frac{3}{4}$ W.	1 $\frac{3}{4}$	40		37.7		13.5
S. S. W. $\frac{3}{4}$ W.	2 $\frac{3}{4}$	27		23.1		13.8
S. W. by W $\frac{1}{4}$ W.	5 $\frac{1}{4}$	27		13.8		23.1
W. by S. $\frac{1}{4}$ W.	7 $\frac{1}{4}$	23		3.4		22.8
W. by N. $\frac{3}{4}$ W.	7 $\frac{3}{4}$	23	1.1			22.9
W. N. W. $\frac{3}{4}$ W.	6 $\frac{3}{4}$	13	3.1			12 [illegible]
				78.0		
			4.2	4.2		108.7
				73.8		

July 2d. Courſe.	Diſt.	N.	S.	[illegible]	W.
S. 55 45 Weſt. Or S. W. by W.	131	—	74	—	109

TRANSACTIONS

TRANSACTIONS.

JULY 1ſt. This afternoon a fine breeze wind ſhifting ſoutherly, at midnight cloſe hauled, on the larboard tack whole topſails on, 1 point and a half leeway.

Sun's meridian altitude - - -	-	65 27 S.
Sun's magnetical amplitude morning -	E.	10 0 N.
True amplitude - -	E.	36 30 N.
Two points and a quarter variation =		26 30 W.

As ſine compliment latitude - -	41 30
: Sine of ſun's declination - -	23 7 N.
: : Radius - - -	90 00
: Sine of ſun's true amplitude - .	36 30 N.

JUNE 30th. Longitude 11 59 W. Latitude 48 53 N.
Diff. of longitude 164 = 2 44 W. - - 47 39
Longitude ſhip - - 14 43 W. 96 32
48 16
Co. middle latitude - - 41 42

N. B. In this day's work after mid night, being cloſe hauled on the larboard tack the 1 point and a half leeway, and 2 points and a quarter variation, go to contrary ſides, whence their difference three quarters of a point allowed as variation to the left or to windward, makes the W. S. W. courſe, S. W. by W. $\frac{1}{4}$ W. &c. as above.

Lat. by Acco.	Departure.	Diff. of lon.	Lon. Ship.
47 39 N.	166	164	14 43 W

Hours.	Courſes.	Knots.	Winds.
2	W. N. W.	6 ½	S. W.
4	——	6	——
6	N. W. by W.	6 ½	S. W. by W.
8	——	7	——
10	N. W.	7 ¼	W. S. W.
12	——	8	——
2	N. W. by W.	7 ½	S. W. by W.
4	W. N. W.	6 ¾	S. W.
6	W. by N.	7	S. W. by S.
8	——	7 ½	——
10	Weſt.	7	S. S. W.
12	——	6 ½	——

Courſes Corrected.	Points	Diſt.	N.	S.	E.	W.
W. N. W ½ W.	6 ½	25	7.3	—		24.
N. W. by W. ½ W.	5 ½	27	12.6	—		23.8
N. W.	4	45.5	32.2	—		32.2
N. W. by W.	5	13.5	7.4	—		11.
W. N. W.	6	29	11.1	—		26.8
W. by S.	7	27		5.3		26.5
			70.6			144.3
			5.3			
			65.3			

July 3d Courſe.	Diſt	N.	S.	E.	W.
N. 65 40 W.	158	65			144
Corrected.		91			132

TRANSACTIONS.

July 2d. This 24 hours variable winds, cloſe hauled, at 4 P. M. ſingle reeft topſails, at 8 double reeft them, at 12 took in both topſails, at 8 more moderate all ſails ſet ; one point and a half leeway till 8P.M, from 8 to 12 two points leeway, from 12 to 8 three points leeway, from 8 to 12 one point leeway.

Variation 2 points weſt.

Sun's meridian altitude	63 52	S.
Sun's declination	23 2	N.
Zenith diſtance	26 8	
Latitude per obſervation	49 10	N.

dep. diff. lat. err. in lat. cor. dep.
∴ 144 : 65 :: 26 : 12 ſubtract

S. co. m. lat. cor. dep. rad. cor. in lon.
and as 42 3 : 12 :: 90 00 : 18

Which alſo ſubtracts. See the Introduction. Page 29

N. B. As the courſe is more than four points from the meridian, we apprehend there is ſome error in the courſe, either by bad ſteerage, leeway, variation or ſome current, which is corrected as above.

Lat. by Acco.	Departure.	Diff. of lon.	Lon. Ship.
48 44 N	310	217	18 20 W.
49 10	298	199	18 2 W

Hours.	Courſes.	Knots.	Winds.
2	Weſt.	6.6	S. S. W.
4	—	6.4	—
6	W. by S.	6.5	S. by W.
8	—	6.4	—
10	W. S. W.	5.8	S.
12	—	5.6	—
2	S. W. by W.	5.5	S. E.
4	—	5.4	S. E. by E.
6	S. W.	5.	—
8	—	5.	E. S. E.
10	S. S. W.	5.	—
12	—	4.9	—

Courſes corrected	Points.	Diſt.	N.	S.	E.	W.
W. by S. ¼ W.	7 ¼	26.		3.8		25.4
W. S. W. ¾ W.	6 ¾	48.6		11.8		47.
S. W. by S. ¼ W.	3 ¼	22.		17.6		13.2
S. S. W. ¼ W.	2 ¼	20.		18.2		8.6
S. ¼ W.	1 ¼	20.		19.4		4.9
				70.8		99.1

July 4th. Courſe.	Diſt.	N.	S.	E.	W.
S. 54 15 Weſt.	122	—	71	—	99

Transactions.

July 3d. A ſtrong gale of wind at 4 P. M. took in our ſmall ſails. at 8 double reeſt topſails, at 12 took in both topſails, and at 8 A. M. ſet them again, moderated, wind ſhiſting eaſterly, at 10 ſaw a veſſel to leeward of us.

Sun's zenith diſtance

Latitude by obſervation

Sun's magnetical amplitude W. 55 51 N.

Variation 1 and three quarters Weſt

The ſun's true amplitude W. 36 10 N. or 53 50 from N.
Magnetical amplitude W. 55 51 N. or 34 90 from N.

Variation 1 $\frac{3}{4}$ = 19 41 W.

Becauſe, when both are reckoned from the north at ſun ſetting, and true amplitude greateſt the variation is weſt. See Introduction, page 22.

Latitude pr. ac.	Departure	Diff. long.	Long. ſhip
47 59 N.	397	150	20 32 W.

Hours.	Courſes.	Knots.	Winds.
2	S. S. W.	5·	E. S. E.
4	—	5 5	—
6	—	6	—
8	S. W. by S.	6 2	—
10	—	6.6	E. by S.
12	—	7·	—
2	—	7·	—
4	S W	7·4	—
6	—	7 7	E. S E.
8	—	8.	—
10	—	8.	S. E. by E.
12	—	8	—
			—

Courſes Corrected.	Points.	Diſt.	N.	S.	E.	W
S. ½ W.	½	33	—	32.8	—	3.2
S. by W. ½ W.	1½	53.6	—	51.2	—	15.8
S. S. W. ½ W.	2½	78.2	—	69.	—	37·
				153.0		56.0

July 5th. Courſe.	Diſt.	N.	S.	E.	W.
S. 20 43 W.	164	—	153	—	56
Corrected.					

TRANSACTIONS.

July 4th. A ſmart breeze, a little increaſing, ſingle reeft topſails at 10 P. M. at 4 A . M. ſhook out the reefs, thick hazy weather, no obſervation.

Magnetical amplitude none

Variation one point and a half weſt

N. B. This day we reckon cape Clear bears from us E. N. E. by our compaſs diſtant 575 miles, and that Corvo one of the weſtern iſles, bears from us S. W. half W. diſtance 532 miles by the firſt caſe of mercator's ſailing.

Lat. per. acco.	Departure	Diff. long.	Long. ſhip
45 26 N.	453	82	21 54 W.

Hours.	Courſes.	Knots.	Half knts	Winds.
2	S. W.	8		W. N. W.
4	——	8		——
6	——	7		——
8	S. W. by W.	7	½	N. W. by W
10	——	7		——
12	S. W. ½ W.	6	½	N. W. by W. ½ W
2	——	6		——
4	——	6		——
6	S. W. by W.	5	½	N. W. by W.
8	——	5		——
10	W. S. W.	5	½	N. W.
12	——	6		——

Courſes Corrected	Points.		N.	S.	E.	W.
S. by W.		46		45.1		9.
S. by W ½ W.	1½	52		49.7		15.1
South		37		37.		
S. ½ W.	1½	21		20.9		2.1
				152.7		26.2

July 6th. Courſe	Diſt	N.	S.	E.	W.
S. 9 50 W.	155	——	153	——	26
Corrected.			190		44

TRANSACTIONS.

July 5th. This 24 hours an increaſing gale, flew out at W. N. W. ſo tacked at 12, at 6 cloſe reeft topſails, at 10 took in both topſails, a ſtorm beginning to appear, at 12 at night more moderate.

A great ſea ſetting S. S. W.
At 12 got an obſervation.

Sun's zenith diſtance	19 30 S.
Declination add	22 46 N.
Latitude per obſervation	42 16 N.

Variation one point and a half weſt.

This day variation and leeway both go to the left hand ſide, ſo that when topſails are in three points leeway, and one and a half variation make four points, whence our S. W. half W. courſe corrects to ſouth, as in the traverſe, table.

N. B. Here by a good obſervation we find the ſhip 37 miles more ſoutherly than by the reckoning, which we attribute partly to the S. S. W. ſea, and as our difference of latitude the three laſt days is 377 and departure only 183, we conclude their may be ſome error in the diſtance. See the Introduction, page 28 and 29.

Lat. per. acc.	Departure	Diff. Long.	Longitude ſhip
42 53 N.	478	36 m.	22 30 W.
42 16 N.	496	262	22 56 W.

∴ Say

∵ Say as difference of latitude	377 m.
: Departure	181 m.
: : The error in latitude	37 m.
: The correction in departure	18 m.
and again,	
As ſine compliment middle latitude	44 17
: Correction in departure	18 m.
: : Radius	90 00
: The correction in longitude	26 m.

Then as the ſhip is before the reckoning, they both add, with reſpect to difference of latitude and departure.

The uſe of the plain Chart in Sailing. See Plate III.

LET us ſuppoſe we ſail out of Mary-port, bound for Dublin in Ireland, being in the offing at *x*, night coming on, lay a ruler to *x* the place of the ſhip, and it appears that a S. W. by S. half W. courſe, carries us clear of the Iſle of Man, therefore allowing two points variation weſt, we ſteer S. W. by W. half W. by the compaſs for eight hours 5 miles an hour, ſo that drawing through *x* a S. W. by S. half W. line, and ſetting thereon 8 × 5 = 40 miles, we reckon at *n* a breaſt of Douglas; Then the wind ſhifting to W. N. W. by our compaſs, ſmall ſails taken in, we lie up to S. W. on the ſtarboard tack, ſo that allowing two points variation and one point and a half leeway to the left hand, our true courſe is then S. half W. having run out 30 miles; we reckon at *m*, wind ſhifting to W. put about on the larboard tack, lies up to N. N. W. puts on all ſails, variation and leway allowed to contrary ſides, makes true courſe N. W. by N. runs out on that courſe 27 miles to *c*, finds we cannot weather the Calf, ſo goes about to S. S. W. variation and leway allowed again, make S. by E. after we had run 18 miles on that courſe to *a*, wind ſhifting to WN. W. and ſhortly after to N. W. we then laid up to W. S. W. by the compaſs ſo that we reckon our courſe S. W. by S.

Having run out 15 miles, we reckon at *b* a breaſt of Holyhead, Wind again ſhifting to N. N. E. by laying a ruler to the ſhip at *b* and to Hoath head we find our true conrſe W. by S. one quarter W. variation allowed makes our compaſs courſe W. N. W. three quarters W. diſtant from Hoath about 57 miles, the wind being fair arived ſafe in 10 hours at Pool Beg.

Traverſe Sailing, by the Chart.

Admit a ſhip at P ſails 1ſt. E. S E 10 m, 2d. S. by E 6 m; 3d. S. by W. 7 m. 4th. N W. by N 8 m. 5th. E. 18 m. 6th S. W. 22 m. 7th N. W 15 m. 8th S W by S 24 m. 9th S. S E. 12 m. 10th N. 7 m. 11th S. W 11 m 12th W. S. W. 15 m. 13th S. W. by S. 19 m. required then her true place on the chart.

SOLUTION.

Lay a rule to P. on the chart the place of the ſhip at firſt, parallel to the 1ſt courſe E S. E. and draw the line P *a* = 10 the diſtance on that courſe; then lay a ruler to *a* the place of the ſhip then, parallel to the 2d courſe S, by E. and draw the line *a b* = 6 the diſtance on that courſe ; and thus proceeding to the end, the ſhip will be found at the points *c. d. e. f. g. h i. k. l. m.* and laſt at N. due eaſt from Drogheda, diſtance about 14 m. her difference of latitude P R. 66 miles, departure R N, 43 miles, diſtance P N. 77 miles, courſe from P ; S. W. by S. nearly. This is called pricking the chart.

The uſe of Mercators Chart is the ſame, only every diſtance ſailed muſt be took from the graduated meridian in or near the parallel of latitude ſailed in.

To find the Latitude of any Place in the Chart, as the Calf of Man.

Take with your compaſſes the neareſt diſtance from the Calf to the parallel 53 30, which meaſured on the ſcale is 23 miles ∵ 53 30 + 23 = 53 53 the latitude of the Calf required.

N. B. If the place propoſed be in a parallel of latitude, the latitude of the parallel is the latitude of the place, as Drogheda latitude 53 30 No. Mary Port 54 30 N.

To find the Longitude of any Place in the Chart; as the Calf of Man.

Take the neareſt diſtance from the Calf to the neareſt leſs meridian 4 30, which meaſured on the ſcale is 17 miles ∵

∴ 4 30 + 17 = 4 47 W. the longitude of the Calf of Man required.

To find the Diſtance of any Two Places in the Chart.

As the diſtance of the point of Ayr, the N. end of the Iſle of man to Whitehaven.

The extent from point of Ayr, to Whitehaven, meaſured on the ſcale makes 32 miles the diſtance required.

To Meaſure the Diſtances of Places on a Mercators Chart.

Case 1ſt If the two places be on the equinoctial line, their diſtance aſunder is expreſſed by that line graduated.

2d If the places are both in the ſame longitude on a meridian, or parallel to a meridian, their diſtance meaſured on the graduated meridian, in their proper parallels is their diſtance aſunder.

3d If the places be both in the ſame latitude, on a parallel of latitude, or parallel to a parallel.

Take the diſtance of the places with a pair of compaſſes, which apply to the graduated meridian ſo that there may be the ſame number of degrees, leagues, or miles, contained between each foot and that parallel on which the places lie; and then the diſtance between the feet of the compaſſes reckoned there is their diſtance aſunder.

4th If the places be in different latitudes and longitudes, neither on a meridian or parallel, nor parallel to meridian or parallel.

Take their difference of latitude, with a pair of compaſſes from the equinoctial.

Then lay a ruler over the two places, and apply one foot of the compaſſes ſo to the ruler's edge, that the other turned about may juſt touch an eaſt and weſt line croſſed by the ruler; then take the diſtance from that foot at the ruler's edge, to that point where the ruler meets the ſaid eaſt and weſt line; which meaſured on the equinoctial line is the diſtance, which was required

A TIDE TABLE, *ſhewing the Hour of High Water on the full and Change Days, to be added to the Time of Moon's ſouthing at any other Age.*

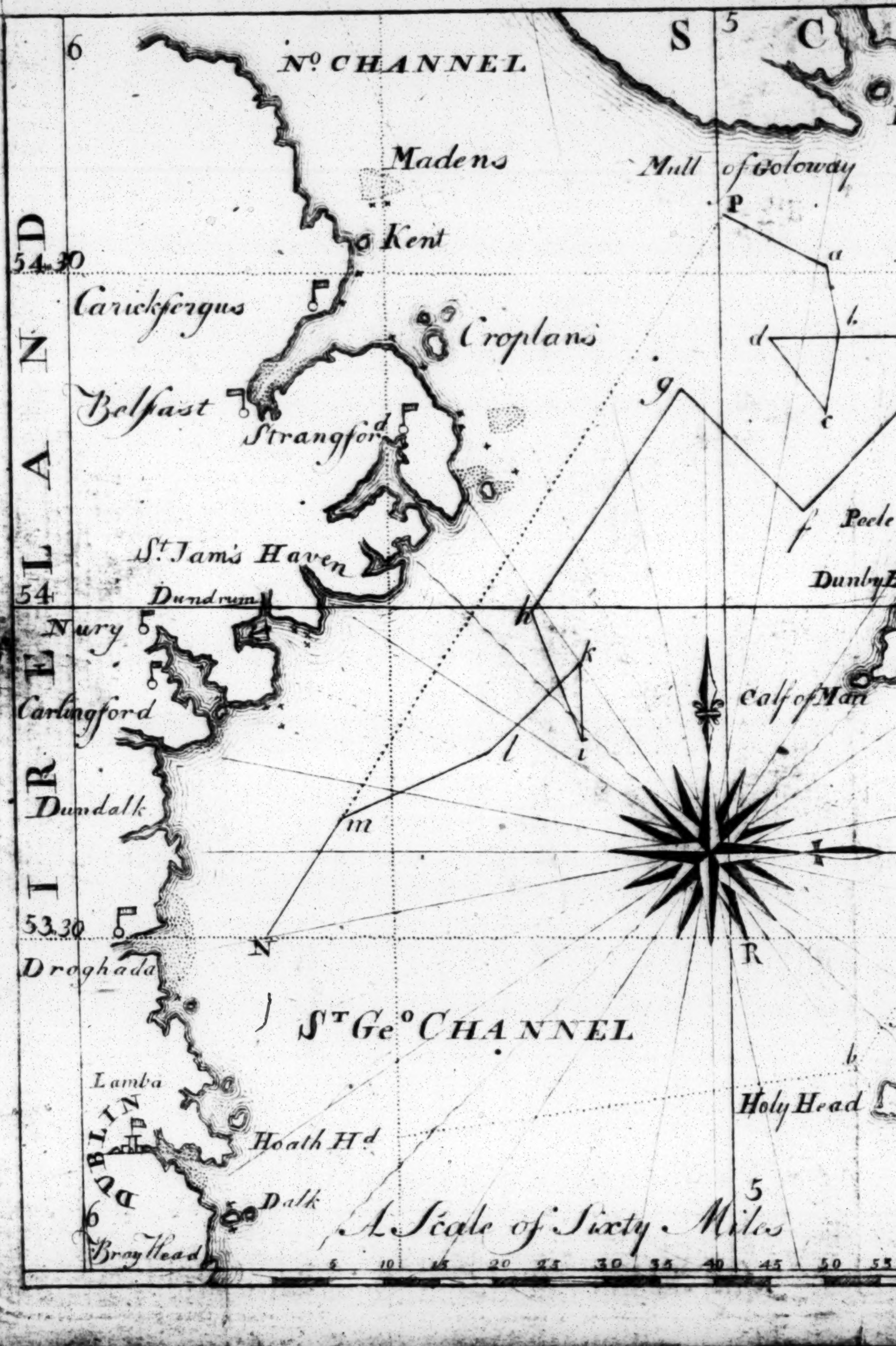
Places on the Coaſt of SCOTLAND.

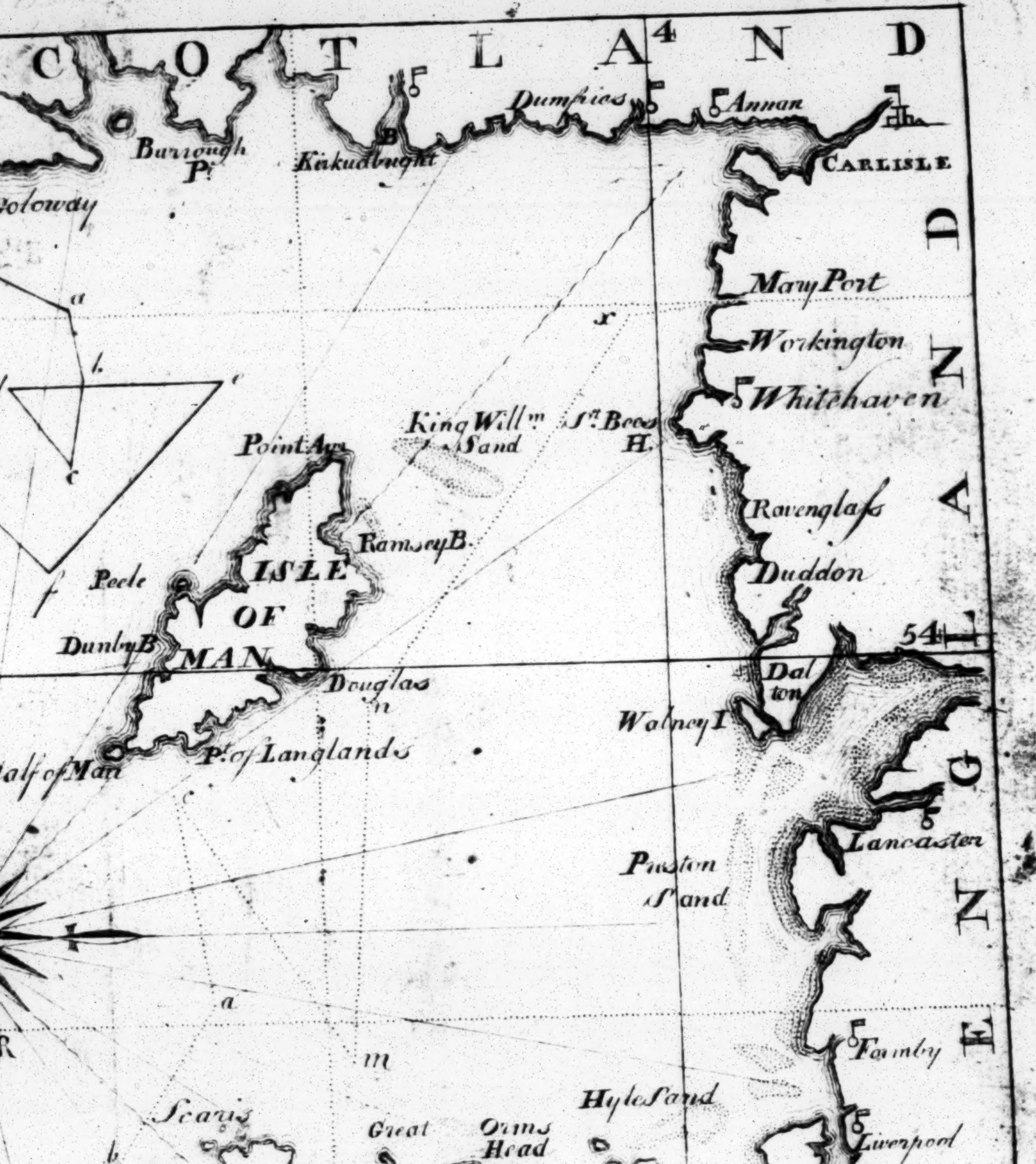
	H.	M.
ABERDEEN	0	45
St. Andrews	2	15
Buchaneſs - -	3	0
Cathneſs - - -	9	0
Dunbar - - - -	2	0
Dundee - - -	2	15
Edinburgh - -	4	30
Leith - - -	4	0
Orkney's - -	6	0
Roſs - -	5	15
Shetland Iſland -	3	0

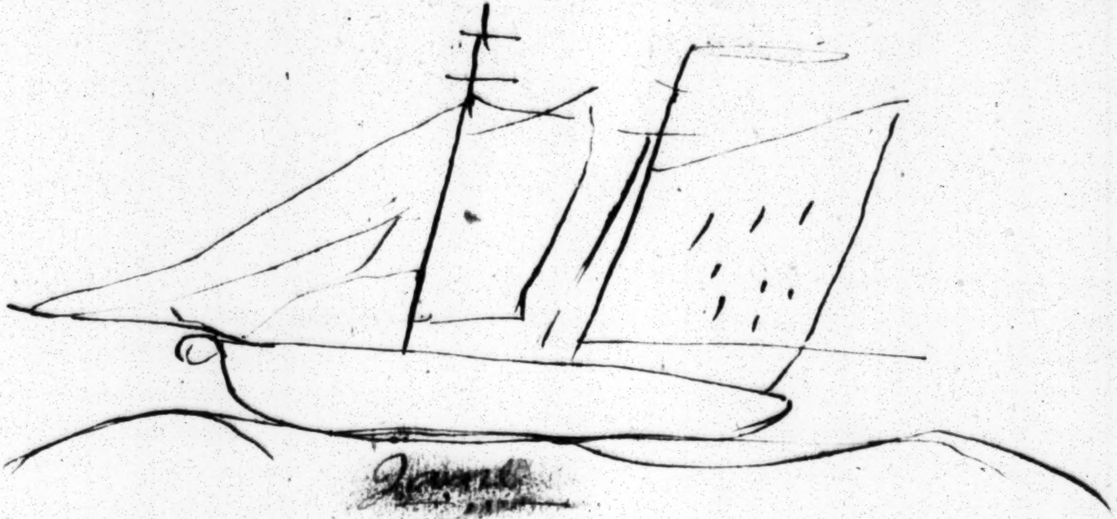
Coaſt of ENGLAND.

	H.	M.
Berwick - -	2	15
Beachy - -	0	0
Bridlington pier -	4	0
Briſtol - -	6	30
——— Key -	6	45
Buoy of nore -	1	0
Dartmouth -	6	30
Deal - -	10	30
Dover - -	11	30
Downs - -	1	15
Dunoſe I. wight	9	45
Dunwich Suff -	9	45
Exmouth - -	6	20
Falmouth - -	5	30
Flamborugh head	4	0
Fluſhing - -	1	0
Foreland N. and S.	9	45
Fowey Cornwall	5	30
Graveſend - -	1	30
Gurnſey Iſland	1	30
Hampton Key -	0	0
Hartlepool Durham	3	0
Harwich Eſſex -	11	0
Haſtings - -	10	30
Hull - -	6	0
Humber-mouth -	5	15
Lands end -	7	30
Lizard - -	7	30
London - -	2	30
Lynn Norfolk -	6	0
Lymn without -	5	15
Margaret road -	11	15
Milford and moonleſs -	5	15
——— Haven	7	30
Newcaſtle - -	3	15
Newport I. wight -	0	0
Nore weſt end - -	0	0
Plymouth - -	6	0
Portland - -	8	30
Portſmouth -	12	30
Rocheſter - -	0	45
Rye - -	11	15
Sandwich -	11	30
Scarbourgh -	3	45
Severns mouth -	6	0
Sheerneſs - -	0	0
Sooreham - -	10	30
Southampton -	0	0
Spit head - -	11	30
Start - -	6	45
Stockton - -	5	15
Thames mouth -	1	30
Tinmouth - -	6	00
Topſham - -	6	0
Torbay - -	6	0
Waſh, Lincon. -	6	30
Weymouth -	7	0
——— Key -	6	45
Whitby -	3	0
Winchealſea -	12	45

Win-


6
N° CHANNEL
S
5
C
Madens
Mull of Goloway
P
Kent
a
54.30
Carickfergus
Croplans
b
d
IRELAND
Belfast
Strangford
d
g
c
f
Peele
St Jam's Haven
Dunby
54
Dundrum
h
Nury
k
Carlingford
Calf of Man
l
i
Dundalk
m
53.30
N
R
Droghada
St Geo CHANNEL
b
Lamba
DUBLIN
Holy Head
Hoath Hd
5
Dalk
6
A Scale of Sixty Miles
Bray Head
5
10
15
20
25
30
35
40
45
50
55


C O T L A N D
4
Burrough P.
Kirkudbright
Dumfries
Annan
CARLISLE
oloway
E N G L A N D
May Port
Workington
Whitehaven
a
x
b
e
c
f
King Willm Sand
St. Bees H.
Point Ayr
Ravenglass
Ramsey B.
Peele
ISLE OF MAN
Duddon
Dunby B
54
Dalton
Douglas
n
Walney I
Pt. of Langlands
alf of Man
Lancaster
Preston Sand
a
R
m
Formby
Hyle Sand
Scaris
Great
Orms Head
b
Liverpool
Holy Head
ANGLESEY
Conway
Carnarvan
CHESTER
5
iles
WALES
4
45 50 55 60
J. Peele Sculpt.



	H.M.		H.M.
Cape Cantin - -	0 0	Nantz river	3 0
—— good hope	3 0	St. Nichols in Ruſſia	6 45
—— Sieree de		Normandy coaſt	10 30
Leone Guinea	8 15	Nor. cape maggero	3 0
Caſkets within	9 45	Peru coaſt	3 0
—— without	8 15	P. deſemſk Ruſſia	6 45
Chili coaſt	3 0	Portugal coaſt	3 45
Deſire point in		Quebeck Canada	6 0
America	0 0	Queenſborough I. Shepy	0 0
Flanders banks	1 0	Rotterdam	3 0
Fin mark coaſt	1 30	St Auguſtin Florida	7 30
Florida	7 30	Scily Iſlands	3 45
Friezland coaſt	7 30	Senegall	10 30
Hague	8 15	Spain weſt coaſt	3 0
St Helens	10 30	Teneriff	3 0
Jutland Iſland	0 0	Zealand coaſt	1 30
Mackwells caſtle	8 15	Zeric ſea	3 00

To find the Golden Number, Dominical Letter, Epact, new and full Moon, Moon's age and Southing, any year to come.

See the Introduction. Pages 30 and 31.

1ſt. Required the Golden Number for 1774.

To the year - 1774
Add - - 1

19) 1775 (93
171
65
57

The golden number - 8 W. W. R.

2d. Required the Dominical Letter for 1774.

Rule. To the year add its 4th. part (omitting fractions) take a 7th. of the ſum, and ſubtract the remainder from 7, then if 1 ſ are A, 2 B, 3 C, 4 D, 5 E, 6 F, or 0 G, is the dominical letter.

1774 the year
quarter = 443
7)2217
376 and 5 remainder

∵ 7—5 = 2 that is, B is the dominical letter.

N. B. 1ſt. In leap year are two dominical letters, one for January and February, and the other to the year's end, this rule gives the latter. If the rule gives B the other is C, if C, the other is D, &c.

2d. Every 4th. year is leap year, or every year diviſible by 4 without remainder is leap year.

3d. *Required the epact for* 1774.

Golden number	8—1 = 7
Multiplied	11
	30)77(2
	60
The epact	17 W. W. R.

4th. *Required the Day of new Moon in May* 1774.

To the epact	17
Add may's number	3
	20
Which ſubtract from	30
New moon the	10th. of May

5th. *Required the Day of full Moon, in October* 1774.

To epact	17
Add October number	8
	25
Which ſubtract from	45
Full moon the	20th. of October

According to the mean motion

6th. Required the Moon's age, on the 25th. of May 1774.

To the epact	17
Add May's number	3
And day	25
	45
Subtract	30
Moon's age	15 Days

7th. Required the Moon's Southing on May 20th. when it is 10 Days old.

Age	10 Days
Multiplied	8
Moon's ſouthing	8 o' Clock

To reckon the tides. See Introduction, page 31.

Required the time of high Water at Edinburgh, when the Moon is 10 Day's old.

	h.	m.
To the ſouthing	8	00
Add from the table	4	30
High water at	12	20

A TABLE *of the Latitudes and Longitudes from* London, *of the principal Harbours, Headlands, Bars, River's Mouths, and Iſlands in the known World, from the beſt Authorities; and thoſe marked thus * from Correct Obſervations.*

On the COAST *of* ENGLAND.

Names of Places		Latitude D. M.	Longitude D. M.
BERWICK	-	55 48 N.	01 40 W.
Newcaſtle	-	55 12	1 30
Sunderland	- -	54 55	1 20

Names of Places	Latitude D.	Latitude M.	Longitude D.	Longitude M.
Whitby	54	26N.	00	50 W.
Humbro-head	54	8	0	11 E.
Spurn	3	45	0	13
Hull	3	52	0	20 W.
Lynn	2	55	0	33 E.
Yarmouth	2	42	1	38
Ipſwich	2	5	1	5
Colcheſter	1	58	0	56
London *	1	31	0	00
Rocheſter	1	28	0	26
Margate	1	27	1	14
The Downs	1	23	1	25
Dover	1	6	1	18
Beachy	50	46	0	25
Portſmouth		49	1	0 W.
I. Wight Newport		42	1	25
Portland		30	2	44
Torbay	50	32	3	39 W.
The Start		7		45
The Edyſtone		10	4	24
Plymouth		31		17
Falmouth		11	5	10
Lizard *	49	55	4	40
Land's end	50	6	6	00
Scilly Iſlands St. Mary's		0		45
Seven ſtones		10		40
Lundy Iſle	51	20	4	40
Mort bay, and point		12		45
Briſtol		33		35
Milford		45	5	15
St. Davids Head	52	00		22
Liverpool	3	20	3	45
Lancaſter	3	47	3	38
Whitehaven	54	22	3	56
Iſle of Man weſt end	3	53	4	48
Holy head		24	4	45

COAST OF SCOTLAND.

Sky Iſland north end	57	45	05	45 W
St. Kilday		52N.	9	45 Lewes

Names of Places.	Latitude D.	M.	Longitude D.	M.
Lewes Iſland north end	58	20N.	07	00 W.
Farro Head or Cape wrath		34	5	10
Shetland ſouth end	60	4	2	00 W
Fair Iſle	59	30	2	20
Iſles of Orkney		10	2	22
Cathneſs point	58	40	4	36
Buchanneſs	57	45	1	18
Aberdeen		22	1	40
Dundee	56	28	2	40
Leith	56	0	2	56
Edinburgh *	55	58	3	0
Glaſcow		52	4	5

COAST OF IRELAND.

Fair Foreland	55	5 N.	06	30 W
Londonderry	55	0	7	50
Belfaſt	55	19	5	42
Iſland Torre	5	9	8	30
Iſles of Arran	4	8		59
Gallaway	3	7	9	40
Limerick	52	23		35
Sline head	3	20	11	15
Blaſques	2	0		56
Shilocks	1	30		55
Cow and Calf	1	22	10	36
Mizen Head	1	16	11	30
Old head of Kinſale	51	35	08	58
Cape Clear		10	10	30
Kinſale		30	09	40
Cork		49	09	30
Waterford	52	9	8	40
Wexford		13	7	28
Dublin	53	12	5	56
Lambay Iſland		24	5	50

COAST OF HOLLAND AND FLANDERS.

Scaw	57	30 N.	10	20 E.
Holy land or heligh land	4	24	08	35
Hamburgh	3	41	10	40

Bremen

Names of Places	Latitude D.	M	Longitude D.	M.
Bremen	53	30N.	09	0 E.
Embden		5	7	35
Schelling		27	6	2
The Fly		16	5	30 E.
The Texel		15		10
Amſterdam *	2	25	5	4
Rotterdam	1	55	4	30
Antwerp		10		20
The Brill	2	0		0
Middleburgh in Zealand	1	37	3	58 E.
Sluys		14		43
Oſtend *		14	3	1
Dunkirk *	51	2	2	27

COAST OF FRANCE AND PORTUGAL.

Calais *	50	58N.	01	54 E.
Dieppe	49	56	1	9
Rouen mouth		34	0	30
Cape Barfleur		43	1	14 W.
—— De la Hogue		47	2	0
Alderney		50		12
Guernſey		33		40
Jerſey	49	15	2	20
St. Maloes *	48	39	1	57 W.
Morlaix		33	3	49
Iſland de Baſs		50	4	0
Uſhant		30	5	2
Breſt *		23	4	26
Weſt Penmark	47	48	4	24 W.
Bell Iſle		18	3	16
Nantz *		13	1	39
Iſland Dieu	46	34	2	13
Hey's Iſland		24		14
Iſles of Oleron	45	56	1	0 W.
Rochel *	46	10		30
Bourdeaux *	44	50	0	34
St. Sebaſtian	43	24	1	27
Bilboa		29	2	58
Cape Pinas		56	6	0 W.
—— Ortegal	44	4	7	48

Names of Places	Latitude D.	M.	Longitude D.	M.	
Cape Corumna or Groin	43	28N.	09	20	W
—— Finiſtere		12		40	W
Oporto	41	10		25	
Rock of Liſbon	38	52		50	
Liſbon *		42	8	53	W.
Cape St. Vincent	36	53	9	6	
—— St. Maria		58	8	30	
Cadiz *		33	6	2	
Cape Trefalgar	36	10	6	1	W.

COAST ON THE CONTINENT WITHIN THE STRAITS.

Gibralter	36	12N.	04	53	W.
Malaga-		48	3	50	
Cape de gat		40	1	40	
Aliant	38	35	0	15	E
Barcelona *	41	26	2	18	
Marſeilles *	43	18	5	27	
Toulon *		7	6	3	
Genoa *	44	25	8	43	
Leghorn *	43	28	10	35	E.
Rome *	41	54	12	34	
Naples *	40	51	14	45	
Venice *	45	25	12	10	
Athens *	38	5	23	57	
Conſtantinople *	41	0	28	58	
Smyrna *	38	28	17	25	E.
Epheſus		1	26	53	
Aleppo *	35	45	13	10	
Jeruſalem *	31	55	35	25	
Alexandria *		-	30	22	
Tripoli	32	54	37	25	
Tunis	36	50	10	17	
Seven Capes	37	15	07	0	
Algier *	36	50	5	16	
Ceuta	35	54	4	45	W.
Tangier		42	3	22	
Tetuan		27	5	6	
Cape Tenes	36	50	1	50	E.
Oran	36	2	0	26	E.

ISLANDS

ISLANDS WITHIN THE STRAITS.

Names of Places	Latitude D.	M.		Longitude D.	M.	
Ivica	38	50	N.	01	40	E.
Majorca	39	30		3	2	
Minorca city		51		4	52	
Port Mahon Minorca		42			12	
Sardinia ſouth end	38	46		9	12	
Corſica ſouth end Bonifacio	41	24			46	E.
—— North end C. Corto.	42	56			50	
Strombello	38	58		16	0	
Trepano weſt end Sicily	37	57		13	13	
Palermo in Sicily	38	6			50	
Cape Paſſaro E. end Sicily	36	38		15	40	
Meſſina in Sicily	38	7		16	20	E.
Syracuſe ditto	37	3		15	45	
Malta *	35	54		14	34	
Cephalonia	38	15		21	30	
Zante	37	46			14	
Rhodes city	36	42		28	5	E.

IN THE ARCHIPELAGO.

Lemnos	39	5[illegible]	N.	25	37	E.
Cape Sygre Metyline		15		26	5	
Scio or Xio	38	22			12	
Patmos	37	20			55	
Millo or Melo	36	40		25	0	
C. St. John W. end Candia	35	15		24	0	
C. Solomon E. end ditto	35	[illegible]		2[illegible]	8	
Rhodes north end	36	2[illegible]		28	38	
—— South end	3[illegible]	[illegible]			28	
Cyprus Cape Baſſa	34	57		32	23	
———— St. Andrea	35	31		35	09	

COAST OF BARBARY AND GUINEA.

Cape Spartil	35	50	N.	05	49	W.
—— Cantin	32	36		9	10	
—— Bajadore	26	4		15	35	
—— Blanco	20	32		17	35	

Senega

Names of Places	Latitude D.	M	Longitude D.	M.
Senegal	15	18N.	16	30 W
Cape de Verd *	14	43	17	5 W.
Month of R. Gambio	13	8	15	31 W.
Sierra Leona	08	36	12	57
Cape Mount	6	23	12	0
River Seſtor or Seſtos	5	24	08	36
Cape de Palmas	4	13	6	45
—— Three points	4	28	1	50 W.
—— Corſe	4	55	2	00
—— Formoſa	4	15	6	40
New Calabar entrance	4	42	8	33
Old Calabar entrance	4	10	9	45
River Angra	0	50	10	1
Cape Lopas	0	55 S.	09	55
—— Negro	16	8	12	31
River Congo	05	40	15	25
Angola	8	57		56
Cape St. Thomas	24	10	14	43
—— Of good Hope *	34	15	17	5

WESTERN ISLANDS.

Corvo	39	54 N.	30	55 W.
Flores (Azores)	32	32		54
Fyal	38	53	28	15
Pico	38	40	27	20
St. George	38	52	26	3
Tercera	38	57	25	34

CANARY ISLANDS.

Sancto Porto	32	58N.	15	54 W
Madiera weſt end	32	23	17	26
Palma	28	40		36
Ferro *	27	54	17	35
Pico Teneriff	28	23	16	28
Grand Canary	27	52	15	10
Forteventura weſt end	28	5	13	36
Lancerota	29	2	12	45W
Allegranſa	29	20	12	33

CAPE DE VERD ISLANDS.

Names of Places	Latitude D.	M.		Longitude D.	M.	
St. Antonia ——	17	24	N.	25	2	W
——Vincent ——	17	4		24	39	
——Lucia or round Iſland	17	5			40	
——Nicholas ——	16	50		23	58	
Iſle de Sal ——	16	50		22	8	
Bona viſta ——	16	5			7	
Mayo or Iſle of May	15	14			2	
St Jago ——	15	8			56	
——Paul ——	01	20	S.	25	30	

SOUTHERN ISLANDS.

Fernando Poo ——	02	40	N.	10	30	E.
De Prince ——	1	40		09	15	
St. Thomas ——	0	0		8	20	
——Matthews ——	1	30	S.	6	1	W
Anna bona ——	2	10		7	27	
Aſcenſion ——	7	20		13	5	
St. Helena Nova ——	16	0		06	14	E.
——Helena * ——	15	56		4	10	W
ſt i an de Acuntia —	37	5		13	50	

EAST INDIES ON THE CONTINENT.

River St. Lucia ——	28	20	S.	32	17	E.
Cape Corientes ——	23	40		36	17	
Cape de Falſo - -	09	0	S.	39	20	E.
River Lamos -	1	20		40	13	
Magadoxa - -	2	20	N.	44	50	
Mocha -	14	10			50	
Cape Reſulgat - -	22	41		59	45	
Gombroon -	27	20		56	40	
Cape Glado - -	25	50		63	34	
Surat * - -	21	10		72	25	E.
Bombay Iſland -	19	18		73	6	
Goa * - -	15	31			50	
Cochin -	09	54		75	55	
Cape Comeria - -	7	50		77	25	

Pond

Names of Places	Latitude D.	M.		Longitude D.	M.	
Pondicherry*	11	54	N	80	18	E.
Fort St. George or Madraſs	13	11			32	
River Bengal	22	17		92	21	E.
Pegu	18	35		96	20	
Malacca*	01	16		102	10	
Siam Entrance	14	18		100	55	
Macao *	22	13		113	51	
Tonguin	20	50		105	40	
Canton *	23	8		113	8	
Nanquin *	33	45		120	1	
Pekin *	39	54		116	28	

ISLANDS IN THE EAST INDIES.

St. Paul	38	20	S.	75	25	E.
Amſterdam Iſle	38	40		72	40	
Mauritius	20	10		52	55	
Madagaſcar Iſland						
Cape St Mary S. End	25	47	S.	46	10	E.
— de Ambre N. End	12	10		51	5	
St. John de Nova	17	21		43	20	
Zanzebar	06	48		39	57	
Coſmedelo	10	14		51	17	
Aſtore Iſland	09	55		53	50	E.
Quivelo Quebello	3	53	S.	52	36	E.
Iſl Gratio	6	10		63	1	
Croſs Iſland	4	10		58	5	
Ceylon S. End	6	8	N.	81	15	
Manila	14	25		117	6	
— N. W. part	19	30		107	0	
— N. E. part	19	55		109	55	
Japan S. E. part	35	30		140	30	
— S W. part	35	00			25	
Bornea	04	50		110	55	
Sumatra N. W. End	5	22		094	50	
—— S. E. End	5	22	S.	105	10	
Bencola	3	55		104	8	E.
Bantam	6	11		105	55	

Names of Places	Latitude		Longitude	
	D.	M.	D.	M.
Batavia	06	16S.	106	46E
Iava E. End	8	32	113	30
Straits of Sunda	6	2	105	46
Borneo S. point	3	54	113	37
Banda Iſles	4	55	127	17
Celebes S. End	5	10S.	119	7
—— N, End	1	40N	121	20
Borneo N. Part	7	40	113	5
Leuconia S. W Part	12	30	120	10
—— N. E. Part	18	55		5
Formoſa S. Part	22	0	119	56
—— N. Part	25	30	120	45

COAST OF AMERICA IN THE SOUTH SEA

Cape St. Sebaſtian	42	45N	127	55W
—— Lucas or Lucia	23	20	111	46
Aquapulca	17	5	104	18W
Panama	08	50	081	52
Iſland Gallopega	0	0	90	10
Lima *	12	1S.	76	44
Arica	18	29	73	10
Iſland Juan Fernandes	33	15S.	88	18w
Port Steven	46	50	82	36
Cape Victory	52	0	83	10
Cape Horn ſouth part of Terra del Fuego	56	55	70	55

COAST OF BRASIL, SOUTH AMERICA.

Le Maire Strait	54	3 4	73	1W
Cape Virgin Mary M. Straits	52	0	75	5
—— Blanco	46	50	72	7
Bay Siffendo	42	35	58	0

River

Names of Places	Latitude D.	Latitude M.	Longitude D.	Longitude M.
River Plate	35	40 S	57	36W
Buenos Ayres *	34	35	58	0
Iſle St, Catherine	27	50	49	0
Cape Frio	23	0	42	20
—— St, Thomas	22	10	42	15
Olinda or Pernambuco*	08	13	35	5
Cape St Auguſtin	8	35	35	20
—— Roque	5	0	35	47
Iſland St, Paul	1	20	25	30
—— Trinidada	20	30	30	0
—— Dos Picos	22	30	25	15
—— St, Maria de Agoſta	19	40	29	10
—— Aſcenſion	67	40	14	25

Coast of the Main Continent in West Indies.

River Amazones mouth	00	0 N	49	56
Cape Orange	4	25	51	25
Surinam	6	25	56	50
Cape Naſſau	8	25	57	55
—— Three points	10	30	62	10
Mouth of Oronoque river	08	15	59	25
Iſland Trinidada	10	15	60	17
Cartagena *	10	27	75	21
Darien or Scot's ſettlement	18	30	78	45
Porto Bello *	19	33	79	45
Cape Honduras	16	25	84	45
—— Catocha	21	10	86	10
Campecha	19	30	92	10
La Vera Cruz	19	12	97	50
Mexico *	20	0	103	35
River Spiritus Sanctus, or Miſſiſipi river's mouth	28	54	096	50
Cape Florida	24	57	80	30
Bay Hondy	22	45	83	40
Cape St, Antonio	21	45	85	32

Caribee Islands.

Tobago weſt end	11	10	59	10
Barbadoes bridge town	12	58	58	50
Granado	11	57	60	20

Names of Places	Latitude		Longitude	
	D.	M.	D.	M.
Granadillos	12	20N	59	55W
St, Vincent	13	12	60	12
—— Lucia	13	55	60	04
Martinico *	14	43	60	54
Dominico	15	23	60	30
Marigalante	15	58	60	20
Gaurda upe	16	10	61	15
Antigua	17	5	61	45
Barbuda	17	56	60	40
Monſerat	16	45	62	15
Rodunda	16	55	61	15
Nevis	17	5	62	32
St, Chriſtopher's	17	17	62	40
Euſtatia	17	25	62	20
St, Bartholomew	17	52	62	6
—— Martins	18	6	62	10
Anguilla	18	17	62	13
Virgins	18	30	63	25
St, Thomas	18	30	63	22
—— John de port Rico	18	30	65	37
Iſles and Rocks of Aves	12	1	64	30
Tortuga	11	10	63	54
Margaritta	11	20	63	20
Bonary	12	12	66	28
Aruba	12	50	68	28
Hiſpaniola St, Domingo	18	25	69	30
——— Eaſt end	18	18	69	15
——— Weſt end	18	26	74	36
Jamaica Port Royal	17	40	76	32
——— Eaſt end	18	0	75	50
———Weſt end	18	8	79	0
Cuba, the Havanna	22	40	82	55
—— Eaſt end	20	15	73	55
—— Weſt end	21	40	86	30

BAHAMA ISLANDS.

Bermudas	32	25	63	40
Bahama bank north part	27	56	78	35
——— Iſland	26	50	79	16
Abaco ſouth end	26	0	73	46
Providence	25	0	77	20

Eleuthera

Names of Places	Latitude		Longitude	
	D	M.	D.	M.
Eleuthera ſouth end	24	40N	75	56W
Watling's Iſland	24	3	74	35
Crooked iſland north end	22	56	74	12
Long iſland ſouth end	22	41	74	52
Atwood's Keys	23	10	73	35
Hogſties	21	17	73	55
Hineago weſt end	20	52	73	46
Abrolho bank north end	21	35	69	6
Pinos	21	20	84	20
Camains greater	18	54	81	29
——— Leſs	19	30	80	24
St, Andreo	12	23	80	17
Pedro ſhoals north ſide	17	10	77	56
St, Milan	17	10	81	28
Cozumelli	19	30	89	5

COAST OF CAROLINA, VIRGINIA, MARY-LAND, PENSILVANIA, NEW ENGLAND, AND NEWFOUNLAND.

Bay of St, Auguſtine	30	10	80	43
Port Royal	32	0	79	43
Charles town upon Aſhley Ri.	33	5	78	46
Cape Fear	33	58	76	54
—— Hatteras	35	15	74	20
—— Henry	37	00	75	24
—— Cape Charles	37	16	74	16
—— Hinlopen or St, James	38	50	74	56
Long Iſland middle	40	50	72	45
New York	40	58	73	53
Block Iſland	41	15	69	58
Elizabeth's Iſland	41	35	69	13
Martha's Vineyard	41	14	69	9
Nantucket's Iſland	41	15	68	48
———— Sheals E. End	39	50	68	18
Boſton entrance	42	30	69	23
Cape Cod	42	12	68	55
Panobſcot River	44	40	67	10
Cape Sable	43	50	64	58
——— Breton	46	50	58	30
Quebeck *	46	55	69	48
Cape St. John	50	25	52	48

Names of Places	Latitude D.	M.	Longitude D.	M.
Cape Bonaviſta	49	15N	52	12W
Virgin Rocks	46	6	57	40
Iſland St. Paul	47	0	58	18
St. John's Harbour	48	10	51	39
Cape Race	46	40	51	52
——— St. Francis	48	9	51	46
Conception Bay entrance	48	20	52	8
Penguin Iſland	50	0	52	50

Coast of Hudson's Bay.

Button's Iſles	60	25	66	28
Cape Charles	62	10	75	35
——— Walſingham	62	35	77	55
——— Jones	54	55	78	58
Bear's Iſland	54	25	83	45
Cubb's iſland	54	10	82	40
Weſton's iſland	52	58	82	48
Danby's Iſland	52	15	80	56
Rupert's River	51	30	79	26
Point comfort	51	34	81	11
Albany fort	52	26	84	50
Cape Henrietta Maria	55	7	84	30
New Severn	56	0	88	20
Cape churchill	59	0	95	20
Sir Thomas Roe's welcome	64	15	92	4
Cape Southampton	61	55	86	48
Shark point	64	30	82	55
Nottingham's Iſland	63	30	79	53
Saliſbury Iſland	63	45	77	15
Queen Ann's foreland	63	48	74	45
Reſoloution Iſland	61	50	65	4
Cape Elizabeth	62	3	66	50
——— Farewell	59	45	46	45

Coast of Iceland, Greenland, Nova Zembla, and the Northern Islands.

Sound Royal	66	22	24	33
Whale's bay	65	27	20	33

Names of Places	Latitude D.	M.	Longitude D.	M.
Grimes Hole, or Guberman's Rocks	66	23 N	29	30 W
Weſtmania iſles	63	30	22	54
Halliford	64	30	34	43
Snow hill	65	11	27	14
Fair foreland	66	20	26	27
Grims Iſland	67	15	22	34
Iſles of Ferro	62	6	05	00
Langeneſs	66	46	12	50
Horn bay	64	50	12	00
Portland	64	2	21	5
John Main's iſland	71	45	04	30 E
Hacluit's headland	79	55	11	0
Charles Iſland				
Cape cold north end	79	00	10	00
Blach point ſouth end	78	00	10	30
Deer ſound	79	15	12	40
Fowl	77	28	12	50
Bel	77	15	12	40
Horn	76	45	13	36
Cape Barcan	78	15	22	11
Edges Iſland				
Cape Blanco	77	45	22	30
Negro point	76	55	23	30
Whale's head	77	18	21	30
Ice point or cape Deſire	77	40	69	10
Admirality Iſland	75	05	56	50
Croſs point	72	00	53	12
Cape Candynoſe	69	05	42	35
—— Barſo	66	30	38	00
Archangel	64	30	40	30
North cape	71	23	23	02
Tromſound Iſland	70	25	15	30
Weiro or Weroy Iſland	67	30	07	30
Dronen or Dronthem	63	40	10	15
North point	62	20	05	26
—— Bergen	60	10	05	40
Naze of Norway	57	45	27	24
Maeſterland	57	53	11	45

COAST OF THE SOUND AND BALTIC.

Maerden or Mardel	58	19	8	57

Names of Places	Latitude		Longitude	
	D.	M.	D.	M.
Caperwick	59	20N	10	10E
Anſloo or Chriſtiana	59	40	10	00
Cape Kol	56	30	12	13
Elſinore	56	22	13	42
Chriſtianople	56	10	16	00
Oeland ſouth end	56	17	15	30
——— North end	57	20	17	00
Stockholm *	59	20	19	30
Ralbergh	60	28	22	35
Pelting ſound	60	32	26	50
Peterſburg *	60	00	30	25
Narva	59	27	28	25
Parnaw	58	30	25	47
Riga	57	04	2[illegible]	15
Der Winda	57	15	22	6
——— Memel	55	48	21	36
Coningſburg	54	43	21	35
Dantzic *	54	22	18	53
Gotland north end	58	00	20	15
——— ſouth end	57	00	17	45
Bornholm	55	15	14	45
Stralſound	54	25	13	16
Wiſmar	54	10	12	00
Lubeck	54	06	09	55
Copenhagen *	55	41	12	50
Moſcow, Ruſſia	55	56	40	25
Uraniburg *	55	54	12	58
Anout or Anholt iſland	56	50	11	06
The Scaw	57	30	10	20
Oſtend	5[illegible]	10	02	46
Greenwich obſervatory	51	29	00	05

The Explanation of the Table of Latitude and Longitude.

The quality of latitude, northing or ſouthing, and of longitude eaſt or weſt, is determined by the initial letters N. S E. W. immediately following the latitude or longitude, but if there be no letter in that line, the next above points out its quality, as Whitehaven in latitude 54 deg, 22m north, longitude 3 deg, 56m weſt, that is latitude north, and longitude weſt. In pages 148 to 152 incluſive, the degrees are frequently ly omitted, (as Briſtol in latitude 51 33 north) the omiſſion muſt be ſupplied by the next number of degrees upwards, and ſometimes the firſt figure of the degrees is omitted as London in latitude 51 31 north, alſo the degrees of longitude are frequently omitted throughout the table, which omiſſion is always ſupplied by the degrees next above as the rock of Liſbon in longitude 9 deg 50m, weſt, Briſtol in longitude 4 deg, 35m, weſt, but Bourdeaux is in longitude 34m, weſt only, &c.

To find the Sun's Declination any Day by the Table.

IF it be a leap year, and an even number of days after March 1ſt. the declination is the ſame as in the Table. Thus in leap year May 20th. the declination 20 deg. 9 min. No. but if the declination be required for an odd day after the 1ſt. of March, as for May 21ſt. then add the number under difference to the declination of the preceeding day thus 20 9 + 13 = 20 22 for the declination that day. Whence this rule for any odd day.

If the declination be increaſing, to the declination of the preceeding day, taken from the table add the difference correſponding for the declination of that day; but when the declination is decreaſing ſubtract the difference from the declination of the preceeding day; and the remainder is the declination for the day required.

Required the ſun's declination on auguſt 13th. 1776 being leap year.

Auguſt 12th the declination is	14 49
from which ſubtract difference	18
⁂ Auguſt the 13 ſun's declination is	14 31 No.

N. B. In leap year reckon for a day leſs than the table in January and February.

Thus January 27th. in leap year the declination is 18 deg 31 So.

Alſo for the 1ſt 2d or 3d. years paſt leap year reckon a quarter, half, or three quarters of a day ſooner, which when the declination is decreaſing adds to the declination found for leap year by the table. But when the declination is increaſing ſubtracts from the declination found in and by the Table as under.

EXAMPLE. required the declination on March 5th. the firſt year after leap year?

March 4th. The declination is	6	07	ſouth
difference per table		24	ſub.
∴ March 5th makes	5	43	
To which add 24 ÷ 4 =		6	
Whence March 5th. the declination is	5	49	ſouth

For the 2d, paſt leap year.

To leap year's declination	5	43
Add 24 ÷ 2 as directed		12
Makes for March 5th. the dec.	5	55

If it had been the third paſt Leap Year.

Then to leap year's declination	5	43	
Add three quarters of 24		18	
Makes for March the 5th. the dec.	6	1	ſouth

The ſun's declination that year.

Again required the Sun's Declination on May the 9th for Leap Year, for the 1ſt. for the 2d. and 3d. paſt Leap Year?

May the 8th. per table declination is	17	18	north
Difference add becauſe increaſing		16	
Sun's declination in Leap Year may 9th. =	17	34	
For 1ſt paſt Leap Year ſubtract 16 ÷ 4 =		4	
Sun's declina. 1ſt paſt Leap Year May 9th	17	30	
Again from Leap Year declination	17	34	
Subtract 16 ÷ 2		8	
Sun's declination 2d. paſt Leap Year	17	26	

Alſo 17 .34 — three quarters of 16 = 17 .22 the ſun's declination May the 9th. the third paſt Leap Year.

A

A Perpetual TABLE *of the* SUN's *Declination.*

	January			February			March		
Days	D.	M.	Dif	D.	M.	Dif.	D.	M.	Dif.
2	22 S.	52	6	16 S.	35	18	6 S.	54	23
4		40	6	15	59			7	24
6		26	7		22	19	5	21	23
8		9	8	14	44		4	34	
10	21	52	8		5	20	3	47	24
12		32	9	13	25		3	0	23
14		11	10	12	45	21	2	13	24
16	20	48	10		3		1	25	23
18		24	11	11	20		0	38	
20	19	58	12	10	38	22	N.	9	24
22		30	13	9	54		0	57	
24		1	15		9		1	41	24
26	18	31	16	8	25	23	2	31	23
28	17	59	16	7	39		3	18	24
30		27	16				4	4	23
31		10	17					28	

	April			May			June		
Days	D.	M.	Dif.	D.	M.	Dif.	D.	M.	Dif.
2	5 N.	14	23	15 N.	37	18	22 N.	19	8
4		59		16	11	17		33	7
6	6	45	22		45			45	6
8	7	30	23	17	18	16		56	
10	8	14	22		50		23	6	5
12		58		18	20	15		14	4
14	9	41	21		49	14		20	3
16	10	24	22	19	17	13		25	2
18	11	6	21		44	14		28	1
20		47		20	9	13		29	0
22	12	27	20		33	12	23	29	1
24	13	7			55	11		27	
26		46	19	21	16	10		23	2
28	14	24	18		36			18	3
30	15	1	19		54	9		11	4
31				22	3				

A Perpetual TABLE *of the* SUN'S *Declination.*

	July			August			Septemb		
Days	D.	M.	Dif.	D.	M	Dif.	D.	M.	Dif.
2	23 N.	2	5	17 N.	38	15	7 N.	41	22
4	22	52	6		7	16	6	56	
6		40		16	34	17		12	24
8		27	7		0	18	5	27	23
10		12	8	15	25	17	4	41	23
12	21	55		14	49	18	3	56	
14		38	9		12	19		10	24
16		18	10	13	34		2	23	23
18	20	57		12	55	20	1	36	23
20		35	11		16		0	50	
22		11	12	11	35			3	23
24	19	46	13	10	54	21	0 S.	44	24
26		20			12		1	31	23
28	18	53	14	9	30	2	2	18	
30		24	15	8	47		3	5	23
31		9			25				

	October			November			December		
Days	D.	M.	Dif.	D.	M.	Dif.	D.	M.	Dif.
2	3 S.	51	23	15 S.	1	19	22 S.	7	9
4	4	38			39	18		24	7
6	5	24	23	16	15			38	
8	6	10			50	17		51	6
10		56	22	17	24	16	23	2	5
12	7	41			57			11	4
14	8	26	22	18	28	15		18	3
16	9	11	22		57	14		24	2
18		55		19	27			27	1
20	10	38	21		55	13		29	0
22	11	20		20	21	12	23	29	
24	12	2			47			26	1
26		44	20	21	6	11		22	2
28	13	24			27	10		17	3
30	14	4	19		49			9	4
31		23						4	5

A Table of the Sun's Amplitudes.

ſun's decl.	D.	Degrees of Latitude.															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
D	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
1	0	0	0	0	0	0	0	0	0	1	1	1	[illegible]	2	2	2	2
2	0	0	0	0	0	0	1	[illegible]	1	2	2	3	3	[illegible]	4	5	[illegible]
3	0	0	0	0	0	1	1	2	2	3	3	4	5	5	6	7	[illegible]
4	0	0	0	0	1	1	2	2	3	4	4	5	6	7	8	10	[illegible]
5	0	0	0	1	1	2	2	2	3	5	6	7	8	9	10	12	13
6	0	0	0	1	1	2	2	3	4	6	7	8	10	11	13	15	17
7	0	0	0	1	1	2	3	4	5	7	8	9	11	13	15	17	19
8	0	0	1	1	2	3	4	5	6	8	9	11	13	15	17	19	22
9	0	0	1	1	2	3	4	5	6	9	10	12	14	17	19	21	25
10	0	0	1	1	2	3	4	6	7	9	11	13	16	19	21	24	28
11	0	0	1	1	2	3	5	6	8	11	13	15	17	20	23	27	30
12	0	0	1	2	3	4	5	7	9	12	14	16	19	22	25	29	33
13	0	0	1	2	3	4	6	8	10	13	15	17	20	24	27	32	36
14	0	0	1	2	3	4	6	9	10	14	16	19	22	26	30	34	39
15	0	0	1	2	3	5	7	9	11	15	17	20	24	28	32	37	42
16	0	1	1	2	4	6	8	10	12	16	19	22	26	30	35	40	45
17	0	1	2	3	4	6	8	10	[illegible]	17	20	[illegible]	28	32	37	42	48
18	0	1	2	3	4	6	8	12	14	18	21	25	30	34	39	45	51
19	0	1	2	3	4	6	9	12	15	19	22	26	31	36	42	48	54
20	0	1	2	3	5	6	9	12	16	20	24	28	33	38	[illegible]	52	57
21	0	1	2	3	5	7	10	13	17	21	25	29	[illegible]	40	[illegible]	[illegible]	60
22	0	1	2	3	5	7	10	13	18	22	27	[illegible]	37	43	49	56	64
23	0	1	2	[illegible]	5	8	[illegible]	16	19	[illegible]	28	[illegible]	39	45	51	58	66
23.29	0	1	2	[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	36	42	47	55	62	71

To take out an Amplitude.

Find the latitude at the top or the neareſt degrees thereto, then againſt the declination, in the angle of meeting, ſtands a number which added to the ſaid declination gives the amplitude there at the time.

Required the ſun's amplitude from the eaſt in latitude 14 deg. north when his declination is 21 degrees north?

A

A Table of the Sun's Amplitudes.

ſun's decl.	Degrees of Latitude ,								
	18	19	20	21	22	23	24	25	26
	m	m	m	m	m	m	m	m	m
1	2	3	4	4	5	5	6	6	7
2	6	7	8	8	9	10	12	12	13
3	9	10	12	13	14	15	17	18	20
4	12	14	16	17	19	21	23	25	27
5	15	17	19	21	23	26	30	33	35
6	19	21	23	26	28	31	34	37	41
7	22	24	27	30	33	37	41	43	48
8	25	28	31	34	38	42	46	50	54
9	28	31	35	39	43	47	51	56	1. 1
10	31	35	39	43	48	52	57	1. 3	1 8
11	34	38	43	48	53	58	1. 3	1 9	1 11
12	38	42	47	52	58	1. 3	1 9	1 16	1 23
13	41	46	51	57	1. 3	1 9	1 15	1 22	1 30
14	44	50	55	1. 1	1 8	1 14	1 21	1 29	1 37
15	47	53	1. 0	1 6	1 13	1 20	1 31	1 35	1 44
16	51	57	1 4	1 11	1 18	1 26	1 34	1 42	1 51
17	54	1. 1	1 8	1 15	1 23	1 31	1 40	1 49	1 59
18	58	1 5	1 12	1 20	1 28	1 37	1 46	1 56	2 6
19	1. 1	1 8	1 16	1 24	1 33	1 42	1 52	2 2	2 13
20	1 4	1 12	1 20	1 29	1 39	1 49	1 59	2 10	2 22
21	1 8	1 16	1 25	1 34	1 44	1 55	2 6	2 18	2 30
22	1 12	1 20	1 29	1 39	1 50	2 1	2 12	2 24	2 37
23	1 15	1 24	1 34	1 44	1 55	2 7	2 19	2 32	2 46
23.29	1 49	1 58	2 8	2 18	2 29	2 41	2 54	3 8	3 23

Here under 14 degrees of latitude againſt 21 degrees declination is 40 m,

∵ 21 deg, + 40m, = 21 deg, 40 the ſun's amplitude at riſing from the eaſt northerly, for the true amplitude is always of the ſame name, north or ſouth as the declination,

A

A Table of the Sun's Amplitudes.

ſun's decl.	Degrees of Latitude								
	27	28	29	30	31	32	33	34	35
1d	8	8	9	9	10	10	11	12	13
2	15	16	17	18	19	21	23	25	27
3	22	24	26	28	30	33	35	38	40
4	29	32	34	37	40	43	46	50	53
5	37	40	43	46	50	54	58	1 2	1 6
6	44	48	52	56	1 0	1 5	1 10	15	20
7	51	56	1 1	1 6	11	16	21	27	33
8	59	1 4	9	15	21	27	33	39	46
9	1 6	12	18	24	31	38	45	52	2 00
10	1 14	1 21	1 27	1 34	1 41	1 48	1 55	2 3	2 12
11	21	28	36	44	52	2 0	2 9	18	28
12	30	37	45	53	2 2	11	21	32	43
13	37	45	54	2 3	13	23	33	44	56
14	45	54	2 3	12	22	33	45	57	3 10
15	1 53	2 3	2 12	2 23	2 34	2 46	2 58	3 11	3 25
16	2 1	11	21	32	44	57	3 1[illegible]	25	40
17	9	20	31	43	56	3 10	24	39	55
18	17	29	41	54	3 7	21	36	53	4 10
19	25	38	51	3 5	19	34	50	4 7	25
20	2 34	2 48	3 2	3 16	3 31	3 47	4 4	4 22	4 41
21	34	57	12	27	43	4 0	18	37	56
22	51	3 6	22	38	55	13	32	52	5 13
23	3 1	16	32	49	47	26	46	5 7	29
23 28	3 37	52	4 8	4 25	4 43	5 3	5 23	5 45	6 5

Required the ſun's amplitude in the evening, in latitude 42 30 north, when the ſun's declination is 12 15 north?

First by the table { Lat. 42 and Decl. 12 the Ampt. is 16 15
{ Lat. 42 Decl. 13 the Ampt. is 17 27

Their difference 1 22 or 82 min. ∴ 60 : 82 :: 15 : 20

Then 16 15 + 20 is 16 35 the amplitude anſwering to 42 deg. latitude and 12 15 declination.

A Table of the Sun's Amplitudes.

ſun's decl.	Degrees of Latitude,								
	36	37	38	39	40	41	42	43	44
1d	[illegible]	15	16	17	18	20	21	22	23
2	29	30	32	34	36	39	41	44	47
3	4	45	48	51	54	58	1 2	1 6	1 10
4	57	1 0	1 4	1 8	1 13	1 18	1 23	28	34
5	1 12	16	21	26	3	38	44	51	58
6	25	31	37	42	50	57	2 5	2 13	2 21
7	40	47	54	2 1	2 9	2 17	26	35	45
8	54	2 2	2 10	19	28	37	47	58	3 9
9	2 8	13	27	37	47	58	3 9	3 21	34
10	21	32	43	51	3 6	3 18	31	44	58
11	39	50	3 1	3 13	26	39	53	4 7	4 22
12	54	3 6	18	31	45	4 0	4 15	31	48
13	3 9	22	35	49	4 4	20	37	55	13
14	24	38	52	4 8	24	42	5 0	5 18	39
15	40	55	4 11	28	[illegible]	4	23	4	6 5
16	55	4 11	28	46	5 [illegible]	25	46	6 8	32
17	4 11	28	46	5 6	2[illegible]	4	6 10	3[illegible]	59
18	27	48	5 [illegible]	25	4	6 1[illegible]	34	5[illegible]	7 26
19	44	5 4	24	4	6 [illegible]	33	58	7 25	54
20	5 0	2	4	6 [illegible]	3[illegible]	5	7 2[illegible]	5	8 23
21	17	39	6 2	27	5[illegible]	7 21	5[illegible]	8 2[illegible]	[illegible]
22	35	5[illegible]	2[illegible]	[illegible]9	7 16	4[illegible]	8 [illegible]	48	9 22
23	52	6 1[illegible]	4	7 11	40	11	[illegible]3	16	51
23 2	6 32	58	7 24	52	8 22	54	9 2	0 3	10 42

Again per table { Lat. 42 Decl. 12 Ampt. is 16 15 north
Lat. 43 Decl. 12 Ampt. is 16 31 north

Their difference is 16 ∴ 60 : 16 :: 30 : 8 whence [illegible] 35 + 8 is 16 43 the amplitude required

A Table of the Sun's Amplitudes

ſun's decl,	Degrees of Latitude,							
	45	46	47	48	49	50	51	52
1d	25	26	28	29	31	33	35	37
2	50	53	56	59	1 3	1 6	1 10	1 15
3	1 15	1 19	1 24	1 29	34	40	46	52
4	40	46	52	59	2 6	2 14	2 22	2 30
5	2 5	2 12	2 20	2 29	38	48	58	3 8
6	30	39	49	59	3 10	3 21	3 33	46
7	56	3 6	3 18	3 30	42	55	4 9	4 24
8	3 21	34	47	4 0	4 14	4 29	45	5 2
9	47	4 1	4 16	31	47	5 5	5 24	43
10	4 13	28	44	5 2	5 21	40	6 1	6 23
11	38	56	5 15	34	54	6 16	39	7 3
12	5 6	5 25	45	6 6	6 28	52	7 18	44
13	33	54	6 16	39	7 3	7 29	57	8 26
14	6 0	6 23	47	7 12	38	8 6	8 57	9 8
15	28	52	7 18	45	8 14	44	9 18	52
16	56	7 23	50	8 20	51	9 24	59	10 36
17	7 25	53	8 25	55	9 28	[illegible]	10 41	1 21
18	54	8 25	5[illegible]	[illegible]	[illegible]	43	[illegible] 24	2 7
19	8 25	58	9 32	10 7	4	25	2 8	55
20	56	9 31	10 [illegible]	47	2	8	54	3 44
21	9 27	10 3	42	23	2 [illegible]	52	3 41	4 34
22	58	37	1 18	2 [illegible]	49	37	4 30	5 27
23	10 30	1 12	56	43	[illegible]	[illegible]	5 23	6 24
23 29	13 20	2 3	2 48	3	4 20	5 2	6 9	7 33

Again, required the ſun's true amplitude in the morning, in latitude 52 48 ſouth, when the the ſun's declination is 22 42 north?

Firſt per table { In Lat. 52 Decl, 22 Ampt, is 37 27 north,
Lat, 52 Decl, 23 Ampt, is 39 24 north,

Their difference is 1 57 = 117min ',' 60 : 117 .: 42 ;82 nearly : Then 37 27 82 is 38 49 the amplitude.

A Table of the Sun's Amplitudes

ſun's decl,	Degrees of Latitude							
	53	54	55	56	57	58	59	60
1d	39	42	45	47	50	53	56	1 0
2	1 20	1 24	1 29	1 34	1 40	1 46	1 53	2 0
3	1 59	2 6	2 14	2 22	2 31	2 40	2 50	3 0
4	2 39	49	59	3 10	3 22	3 34	3 47	4 1
5	3 19	3 31	3 44	57	4 11	4 26	4 43	5 2
6	4 0	4 15	4 30	4 47	5 4	5 22	5 42	6 4
7	40	57	5 15	5 35	56	6 18	6 41	7 6
8	5 21	5 41	6 2	6 24	6 48	7 14	7 41	8 10
9	6 4	6 26	49	7 14	7 45	8 10	8 41	9 14
10	46	7 11	7 37	8 5	8 33	9 7	9 41	10 18
11	7 29	57	8 26	56	9 29	10 4	10 4	1 26
12	8 12	8 43	9 15	9 49	10 25	1 4	1 4[illegible]	2 34
13	57	9 30	10 5	10 43	1 23	2 7	2 54	3 44
14	9 42	10 18	56	1 37	2 21	3 9	4 1	4 55
15	10 28	1 7	1 49	2 34	3 22	4 14	5 12	6 9
16	1 16	58	2 43	3 32	4 24	5 21	6 22	7 27
17	2 4	2 50	3 39	4 31	5 27	6 28	7 32	8 47
18	53	3 42	4 35	5 33	6 34	7 40	8 53	20 9
19	3 45	4 [illegible]8	5 35	6 36	7 46	8 54	20 13	1 36
20	4 39	5 35	6 36	7 42	8 53	20 12	1 37	3 10
21	5 31	6 37	7 39	8 51	20 9	1 34	3 5	4 48
22	6 29	7 26	8 47	20 4	1 27	2 59	4 40	6 32
23	7 29	8 40	9 56	1 1[illegible]	2 50	4 30	6 [illegible]	[illegible] 2[illegible]
23 29,	8 2[illegible]	9 46	21 0	2 27	4 2	5 46	7 47	9 51

Again { Lat, 52 Decl, 22 Ampt, 37 27
{ Lat, 53 Decl. 22 Ampt, 38 29

the difference of theſe amplitudes is 1d, 2m, or 62 minutes, ∴ 60 : 62 : : 48 : 49 nearly, ſo that 38 49 + 49 makes 39 38 the amplitude from the eaſt northerly.

A TABLE
OF
MERIDIONAL PARTS
OR THE

Meridian lengthened in miles according to MERCATOR's projection, to all latitudes from the equator to 84 degrees north or ſouth.

To find the Meridional parts anſwering to any Latitude.

1. IN latitude 1. 2. 3. 4. 5. degrees north or ſouth, the difference of latitude and meridional difference of latitude differ not a mile.

Then for any number of degrees from 6 to 84, with 10. 20. 30. 40. or 50. minutes, you have the meridional parts by inſpection in the table as the meridional parts for 58 30. are 4352 miles.

To find the Meridional parts for 58 35

1ſt The parts for 58 30 are 4352, and in the column of difference ſtands 1. 9. which × 5 = 9. 5. whence 4352 + 9 = 4361 miles the meridional parts for 58 35.
Whence the following rule for any latitude, write out the meridional parts to the neareſt latitude, multiply the minutes wanting by the difference, and add that product to the meridional parts aforeſaid for the anſwer.

Required the Meridional parts for Latitude 52 28
Latitude 52 20 meridional parts are 3698
minutes wanting 8 × difference 1. 6. = 12. 8 or 13 nearly

⁂ meridional parts for 52.28 are = 3711 W. W. R:

Again Required the Meridional parts for Latitude 38 47
Latitude 38 40 the meridional parts are 2519
minutes wanting 7 × 1. 3 difference = 9. 1 or 9

⁂ meridional parts for 38 47 are = 2528

A Table of Meridional Parts.

D M	MP	d	D M	M P	D	D M	M P	D	D M	M P	D
6 0	361	1	12 0	725	1	18 0	1098	1 ,1	24 0	1484	1 ,1
10	371		10	735		10	1109		10	95	
20	381		20	746		20	19		20	1506	1 ,1
30	391		30	756		30	30		30	17	
40	401		40	766		40	40		40	28	
50	411		50	776		50	51		50	39	
7 0	421	1	13 0	787	1 .1	19 0	1161	1 ,1	25 0	1550	1 ,1
10	431		10	797		10	72	1	10	61	
20	441		20	807		20	83		20	72	
30	451		30	817		30	93		30	83	
40	461		40	828		40	1204		40	94	
50	471		50	838		50	14		50	1605	
8 0	481	1	14 0	848	1 .1	20 0	1225	1 ,1	26 0	1616	1 ,1
10	492		10	859		10	36		10	28	
20	502		20	869		20	46		20	39	
30	512		30	879		30	57		30	50	
40	522		40	890		40	68		40	61	
50	532		50	900		50	78		50	72	
9 0	542	1	15 0	910	1 ,1	21 0	1289	1 ,1	27 0	1684	1 ,2
10	552		10	921		10	1300		10	95	
20	562		20	931		20	11		20	1706	
30	573		30	941		30	21		30	17	
40	583		40	952		40	32		40	28	
50	593		50	962		50	43		50	40	
10 0	603	1	16 0	973		22 0	1354		28 0	1751	1 ,2
10	613		10	983		10	64		10	62	
20	623		20	993		20	75		20	74	
30	633		30	1004		30	88		30	85	
40	644		40	1014		40	97		40	97	
50	654		50	1025		50	1408	1 ,1	50	1808	
11 0	66		17 0	1035	1 ,1	23 0	1419		29 0	1819	1 ,2
10	674		10	1046		10	29		10	31	
20	68		20	1056		20	40		20	42	
30	695		30	1067		30	51		30	54	
40	70		40	1077		40	62		40	65	
50	[illegible]		50	1088		50	73		50	77	
12 0	[illegible]		18 0	1098	1 1 1	24 0	148	1 ,	30 0	188	1, 2

A Table of Meridional Parts.

D M	Parts	D	D M	Parts	D	D M	Parts	D
30 0	1888	1,2	36 0	2318	1,2	42 0	2782	1,3
10	1900		10	30		10	95	
20	11		20	43		20	2809	
30	23		30	55		30	22	
40	35		40	68		40	36	
50	46		50	80		50	49	
31 0	1958	1,2	37 0	2393	1,2	43 0	2863	1,3
10	70		10	2405		10	77	
20	81		20	18		20	90	
30	93		30	30		30	2904	
40	2005		40	43		40	18	
50	17		50	55		50	32	
32 0	28	1,2	38 0	2468	1,3	44 0	2946	1,3
10	40		10	81		10	59	
20	52		20	94		20	74	
30	64		30	2506		30	88	
40	76		40	19		40	3002	
50	88		50	32		50	16	
33 0	2100	1,2	39 0	2545	1,3	45 0	3030	1.4
10	11		10	58		10	44	
20	23		20	71		20	58	
30	35		30	84		30	73	
40	47		40	97		40	87	
50	59		50	2611		50	3101	
34 0	2171	1,2	40 0	22		46 0	16	1,4
10	83		10	36		10	30	
20	96		20	49		20	44	
30	2208		30	62		30	59	
40	20		40	75		40	73	
50	2		50	88		50	88	
35 0	2244	1,2	41 0	2702	1,3	47 0	3203	1,5
10	56		10	15		10	17	
20	69		20	28		20	32	
30	81		30	41		30	47	
40	93		40	55		40	62	
50	2306		50	68		50	77	
36 0	18	1,2	42 0	2782	1.3	48 0	3292	1,5

A Table of Meridional Parts.

D M	Mil.	D	D M	Mil.	D	D M	Mil.	D
48 0	3292	1,5	54 0	3865	1,7	60 0	4527	2,
10	3307		10	82		10	47	
20	22		20	99		20	68	
30	37		30	3916		30	88	
40	52		40	33		40	4608	
50	67		50	51		50	29	
49 0	3382		55 0	68		61 0	49	2,1
10	97		10	86		10	70	
20	3413		20	4003		20	91	
30	28		30	21		30	4712	
40	43		40	38	1,8	40	33	
50	59		50	56		50	54	
50 0	3475	1,5	56 0	74	1,8	62 0	75	2,1
10	90		10	92		10	97	
20	3506		20	4110		20	4818	
30	21		30	28		30	40	
40	37		40	46		40	61	
50	53		50	64		50	83	2.2
51 0	3569	1,6	57 0	83		63 0	4905	2,2
10	85		10	4201		10	27	
20	600		20	20		20	50	
30	17		30	38	1,9	30	72	
40	33		40	57		40	94	
50	49		50	76		50	5017	2,3
52 0	3665	1,6	58 0	94	1,9	64 0	40	2,3
10	82		10	4313		10	63	
20	98		20	32		20	86	
30	714		30	52		30	5109	
40	31		40	71		40	32	
50	47		50	90		50	56	
53 0	764	1,7	59 0	4409	2,	65 0	79	2,4
10	80		10	29		10	5203	
20	97		20	48		20	27	
30	3814		30	68		30	51	
40	31		40	88		40	75	
50	48		50	4508		50	99	
54 0	865		60 0	27		66 0	5324	

A Table of Meridional Parts.

DM	M.P	D	D M	Mil.	D	D M	Miles	D
66 0	5324	2,5	72 0	6335	3,2	78 0	7745	4,9
10	49		10	67	3,3	10	94	
20	73		20	6400		20	7843	5,
30	98		30	33		30	93	
40	5424		40	67		40	7943	5,1
50	49		50	6500	3,4	50	94	5,2
67 0	74	2,6	73 0	34		79 0	8046	5,3
10	5500		10	69	3,5	10	99	5,4
20	26		20	6603		20	8153	
30	52		30	38	3,6	30	8206	5,5
40	78		40	74		40	262	5,6
5	5605		50	6710		50	318	5,7
68 0	31	2,7	74 0	46		80 0	375	5,8
10	58		10	82	3,7	10	433	5,9
20	85		20	6819		20	492	6,1
30	5712		30	56	3,8	30	553	
40	40		40	94		40	614	6,2
50	67		50	6932		50	679	6,3
69 0	95	2,8	75 0	70	4,0	81 0	739	6,5
10	5823		10	7010		10	804	6,6
20	51		20	50		20	870	6,7
30	80	2,9	30	90		30	937	6,8
40	5909		40	7130		40	9 005	7,
50	36		50	70		50	075	7,1
70 0	66		76 0	7210	4,2	82 0	146	7,3
10	95	3,0	10	52		10	219	7,4
20	6025		20	95	4,3	20	293	7,5
30	54		30	7338		30	368	7,8
40	84		40	81		40	446	7,9
50	6115		50	7424		50	525	8,1
71 0	46		77 0	67	4,4	83 0	606	8,3
10	76		10	7511	4,5	10	689	8,5
20	6207	3,1	20	57	4,6	20	774	8,8
30	39		30	6704		30	862	8,9
40	70	3,2	40	50	4,7	40	951	9,2
50	6302		50	97	4,8	50	10043	9,4
72 0	35		73 0	7745		84 0	137	

A TABLE OF DIFFERENCE OF LATITUDE. AND DEPARTURE.

For degrees, points, and quarter points, ſufficiently exact to determine the courſe, diſtance, and difference of longitude, by middle latitude ſailing as far as 120 miles and by a peculiar artifice to 10 times that diſtance.

The uſe of the tables of difference of latitude and departure, for ready computation in working any of the caſes of *Plain Sailing*.

In theſe new tables, the courſe if leſs than 4 points or 45 degrees, is found in the firſt column on the left hand ſide; but if more than 4 points or 45 degrees it is found in the laſt column to the right hand ſide, the diſtances are at the top of each page, and when the courſe is on the left hand ſide, the titles for difference of latitude and departure are at the top, but when the courſe is on the right hand ſide of the page the titles are at the bottom as is evident by inſpection.

CASE 1ſt Courſe and diſtance given, to find the difference of latitude and departure.

RULE Find your diſtance at top, then againſt the courſe, take the difference of latitude and departure out of the columns marked latitude and departure and its done.

EXAMPLE A ſhip ſails N. N, W 97 miles; required her difference of latitude and departure?

Having found my diſtance 97 *m* at top; againſt 2 points is 89.6 the difference of latitude and 37.1 the departure.

N. B. The laſt figures in the columns of latitude and departure are underſtood to be decimals.

CASE 2d. Courſe and difference of latitude given; to find diſtance and departure.

RULE Find the given difference of latitude under or over its title according as the courſe is leſs or more then 4 points, then at top is the diſtance, and departure adjoining.

Example A ſhip ſails N. E. by N. until her difference of latitude be 75 miles, required the diſtance and departure?

Run your eye down the collums of latitude from top, becauſe the courſe is under 4 Points, ſo that you find the neareſt number to 75; which is 74.8 againſt 3 points, then at top you have the diſtance 90 miles, and departure 50 W. W. R.

Case 3d. Courſe and departure given to find diſtance and difference of latitude.

Rule Find your departure in a departure column from top or bottom according as the courſe is under or above 4 points, and you have the diſtance and difference of latitude as directed in the laſt caſe.

Example A ſhip ſails N. E. by E. ½ E. until her departure be 85 miles and ½ required her diſtance and difference of latitude?

Here I run my eye up and down the columns of departure from bottom, becauſe my courſe is more than 4 points, and find 85.6 againſt the courſe 5 ½ points, which gives the diſtance 97 miles and the difference of latitude 45.7 miles W. W. R.

Case 4th. Diſtance and departure given; to find courſe and difference of latitude.

Rule Put two cyphers to the departure, or three if it have no tenths with it, and divide by the diſtance note the quotient, which find in the table of numbers after the tables of latitude and departure, in the columns belonging to diſtance and departure or the neareſt thereto, and the degrees anſwering is the courſe, and for the difference of latitude proceed as in caſe 1ſt.

Example A ſhip ſails between the N. and W. until her diſtance be 94 miles and departed her meridian 61.7 miles, required the courſe and difference of latitude?

Having put two cyphers to my departure it becomes 61.700, which divided by 94 gives 656, againſt which in the table is 41 degrees the courſe, or N. W. by N. ½ W. nearly; then againſt courſe 41 degrees under diſtance 94 *m* is 70.9 or 71 miles the difference of latitude nearly.

Case 5th. Diſtance and difference of Latitude given; to find courſe and departure.

Rule Put cyphers to the departure, and divide by the diſtance as in the laſt caſe, then find the neareſt number to the quotient in the table for that purpoſe, and the degrees correſponding is the courſe, as before directed, then find the difference of latitude as directed in caſe 1ſt.

EXAMPLE A ſhip ſailed into the ſouth weſt quarter 89 miles, and they found the difference of latitude by a good obſervation 77 miles, required the true courſe and departure?

Here I put three cyphers to the departure and it becomes 77000 which divided by 89 gives 865, and in the table of numbers for that purpoſe, I find the neareſt number 866, which gives courſe 30 degrees then againſt courſe 30 in the table of latitude and departure is 44.5 miles the departure, W. W. R.

CASE 6th. Difference of latitude and departure given, to find courſe and diſtance.

RULE Put two or three cyphers if it have no tenth parts to the departure, and divide by the difference of latitude, then look in the table of numbers under difference of latitude and departure for the neareſt number to the quotient. the degrees or points anſwering to that number is the courſe. Then for diſtance proceed as in caſe 2d or 3d.

EXAMPLE A ſhip ſails between the ſouth and eaſt till her difference of latitude is 85*m*. and her departure 38*m*. required her courſe and diſtance?

Having put cyphers to the departure it becomes 38000, and the difference of lat. becomes 850, by ſupplying the tenths place, the former divided by the latter gives 44.7 the neareſt number in the table is 45, which gives 24 degrees the courſe, and with that courſe and departure (by caſe 3d) or by that courſe and difference of latitude (by caſe 2d) the diſtance will be found 93 miles W. W. R.

Traverſe Sailing.

The ſeveral courſe and diſtances a ſhip ſails being given; to find her difference of latitude and departure, with courſe, and diſtance made good.

Make a table as follows, in which enter all your courſes and diſtances, after all allowances are deducted, for leeway and variation, then mind that the northing or ſouthing of every courſe belongs to difference of latitude, and the eaſting or weſting belongs to departure, and muſt be each regularly placed in the traverſe table under their reſpective

Initials N. S. E. or W. that is, if the courſe be northerly the difference of latitude muſt be ſet in the north column under N. if ſoutherly in the ſouth column under S. alſo it the courſe be eaſterly, the departure muſt be ſet in Eaſt column under E. if weſterly in the weſt column under W.

Then, add up all your columns, and take the difference of the ſums of the N. and S. columns, if need be, for differance of latitude, alſo get the difference of the ſums of the eaſt and weſt columns if there be numbers in both, for the departure. and with that difference of latitude find courſe and diſtance as in caſe 6th. of plain ſailing.

EXAMPLE If a ſhip ſails the following courſes viz. S. S. W. 55 miles, W. by S. 38 miles N. W. by N. 40 N. E. by E. 69 and N. N. W. 60 miles, required the difference of latitude and departure, with direct courſe and diſtance?

		Diff. of latitude		Departure	
Courſes.	Diſt.	North.	South.	Eaſt	Weſt
S. S. W.	55		50.8		21
W. by S.	38		7.4		37.3
N W b N	40	33.3			22.2
N E b E	69	38.3		57.4	
N. N. W.	60	55.4			23
		127.0	58.2	57.4	103.5
		58.2			57.4
Diff. lat. north		68.8		Dep. W	46.1

Courſe 3 points or N. W. by N. nearly, diſtance 82 miles.

N. B. By this method are difference of latitude and departure found, when working a days work at ſea, and thence are found courſe and diſtance, and difference of longitude, with latitude and longitude ſhip by dead reckoning.

Parallel Sailing by the Tables.

Here you muſt work with diſtance ſailed (by the preceeding directions) as if it were departure, compliment of latitude as courſe, and difference of longitude as diſtance.

Ex

EXAMPLE If a ſhip ſails due eaſt 65m in the latitude of 55 degrees north, required her difference of longitude?

90 — 55 = 35 the compliment of latitude, as courſe, then looking in a departure column for 65. againſt 35 degrees I find 64.8 which gives the difference of longitude in the diſtance column 113, which was required.

Mercator's Sailing.

In working with the difference of longitude, or for it, you muſt work as if it were a departure, and the meridional dif.of latitude muſt be worked with as if a difference of latitude.

EXAMPLE in caſe 1ſt what courſe and diſtance muſt a ſhip ſail from cape clear in latitude 51 10 north, longitude 10 30 weſt, to the iſland Corvo one of the weſtern iſlands, latitude 39 54 N. Longitude 30 55 W.

		M Parts		
Lat. ſailed from	51 10	3585	Long. ſailed from	10 30
Lat. bound to	39 54	2615	Long. bound to	30 55
	11 16	970		20 25
	60	× lat		60
Diff. of Lat.	676 mil.		Diff. of Long.	1225 mil

By putting two cyphers to the difference of longitude, and dividing by the meridional difference of latitude, the quotient is 126 the neareſt to which in the table of numbers, under difference of latitude and departure is 128, againſt which is 52 degrees the courſe South weſterly, then with that courſe, and the difference of latitude 676 ÷ 10 = 67.6 in the table of latitude and departure, the diſtance is found 110 which multiplied 10 is 1100 miles W. W. R.

Middle Latitude Sailing.

Here the difference of longitude muſt be worked as diſtance with the departure, and compliment of middle latitude as courſe.

Let the laſt example be done by middle latitude.

Latitude ſailed from 51 10
Do. bound to 39 54
½) 91 04
45 32
90 00
the comp. of mid. lat. 44 28

Difference of longitude as before 1225 miles divided by 20 gives 61,2

In the table of difference of latitude and departure under 61 againſt 44 ſtands 42 2 which multiplied 20 (becauſe the difference of longitude was divided by 20) gives 844 the departure, to which anexing two cyphers and dividing by the difference of latitude the quotient is 124, which in the table for that purpoſe gives 52 degrees the courſe ſouth weſterly as before; whence the diſtance will be the ſame viz. 1100 miles.

Again both latitudes and departure given; to find the difference of longitude.

Admit a ſhip from the latitude 56 50 North, ſails ſouth weſterly until ſhe be in latitude 54 20, departure being 218, required the difference of longitude?

Here the compliment of middle lalitude is 34 30 and the neareſt degree in the table is 35 which being worked as courſe, with a 10th of the departure 21.8 for diſtance gives 38 which × 10 = 380 the difference of longitude, or if you work with 3 points it makes the difference of longitude 390 whence 390 + 360 ÷ 2 = 385 the difference of longitude required,

Or by Mercator's ſailing the meridional difference of latitude is 247, courſe 57 degrees 7min. the neareſt number of degrees in the table is 58 degrees or 5 points, now the difference of longitude correſponding to the meridional difference of latitude 247 courſe 58 degrees is 399, and ditto courſe 5 points in the table is 366 whence 399 + 366 ÷ 2 gives 382 the difference of longitude required, nearly agreeing with middle latitude.

A Traverſe Table,

	1		2		3		4		5		6		7		8		
PD	L,	D.	L,	D,	L,	D	L,	D,	L,	D	L,	D,	L,	D	L,	D,	PD
1	10	,1	20	,1	30	,1	40	1	50	1	60	1	70	1	80	01	89
2	10	,1	20	,1	30	,1	40	1	50	2	60	2	70	2	80	03	88
1 q	10	,1	20	,1	30	,1	40	2	50	2	60	3	70	3	80	04	3 q
4	10	,1	20	,1	30	,2	40	3	50	3	60	4	70	5	80	06	86
2 q	10	,1	20	,2	30	,3	40	4	50	5	60	6	70	7	80	08	2 q
7	10	,1	20	,2	30	,4	40	5	50	6	60	7	69	8	79	10	83
3 q	10	,1	20	,3	30	,4	40	6	50	7	59	8	69	10	79	12	1 q
9	10	,2	20	,3	30	,5	39	6	49	8	59	9	69	11	79	12	81
10	10	,2	20	,3	29	,5	39	07	49	9	59	10	69	12	79	14	80
1	10	,2	20	,4	29	,6	39	8	49	10	59	11	69	14	78	16	7
12	10	,2	20	,4	29	,6	39	8	49	10	59	12	68	15	78	17	78
13	10	,2	19	,4	29	,7	39	9	49	11	58	13	68	16	78	18	77
1 q	10	,2	19	,5	29	,7	39	10	48	12	58	14	68	17	78	19	3 q
15	10	,3	19	,5	29	,8	39	10	48	13	58	15	68	18	77	21	75
16	10	,3	19	,5	29	,8	38	11	48	14	57	16	67	19	77	22	74
2 q	10	,3	19	,6	29	,9	38	11	48	15	57	17	67	21	76	23	2 q
18	9	,3	19	,6	28	,9	38	12	48	15	57	18	67	22	76	25	72
19	9	,3	19	,6	28	10	38	13	47	16	57	19	66	23	76	26	71
3 q	9	,3	19	,7	28	10	38	13	47	17	56	20	66	24	76	27	1 q
21	9	,4	19	,7	28	11	37	14	47	18	56	21	65	25	75	29	69
2	9	,4	18	,8	28	11	37	15	46	19	55	23	65	27	74	31	6
24	9	,4	18	,8	27	12	36	16	46	20	55	24	64	28	73	32	66
1 q	9	,4	18	,9	27	13	36	16	45	21	54	26	63	30	72	34	3 q
26	9	,4	18	,9	27	13	36	17	45	22	54	26	63	31	72	35	64
27	9	,4	18	,9	27	14	36	18	45	23	53	27	62	32	71	36	63
2 q	9	,5	18	,9	26	14	35	19	44	24	53	28	62	33	70	38	2 q
29	9	,5	17	10	26	14	35	19	44	24	52	29	61	34	70	39	61
30	9	,5	17	10	26	15	35	20	43	25	52	30	61	35	69	40	60
3 q	9	,5	17	10	26	15	34	21	43	26	51	31	60	36	69	41	1 q
32	8	,5	17	11	25	16	34	21	42	26	51	32	59	37	68	42	58
3	8	,6	17	11	25	17	33	22	42	28	50	33	58	39	67	44	5
35	8	,6	16	11	25	17	33	23	41	29	49	34	57	40	65	46	55
1 q	8	,6	16	12	24	18	32	24	40	30	48	36	56	42	64	48	3 q
38	8	,6	16	12	24	18	32	25	39	31	47	37	55	43	63	49	52
2 q	8	,6	16	13	23	19	31	25	38	32	46	38	54	44	62	51	2 q
41	7	,7	15	13	23	20	31	26	37	33	45	39	53	46	60	52	49
3 q	7	,7	15	13	22	20	29	27	37	34	44	40	52	47	59	54	1 q
43	7	,7	15	14	22	20	29	27	36	34	44	41	51	48	58	55	47
44	7	,7	14	14	22	21	28	28	36	35	43	42	50	49	57	56	46
4	7	,7	14	14	21	21	28	28	35	35	42	42	49	49	57	57	4
PD	D.	L,	D,	L,	D,	L,	D	L,	D	L,	D,	L,	D,	L,	D,	L,	PD

A Traverſe Table.

Co.	9		10		11		12		13		14		Co.
P D	L,	D.	L,	D.	L,	D.	L,	D.	L,	D.	l	D.	D
1	90	02	100	02	110	02	120	02	130	02	140	02	89
2	90	03	100	04	110	04	120	04	130	05	140	0	88
1 q	90	04	100	05	110	05	120	05	130	06	140	07	3 q.
4	90	06	100	07	110	08	120	07	130	09	140	10	86
2 q.	90	09	100	10	109	11	119	11	129	13	139	14	2 q.
7	89	11	99	12	109	13	119	15	129	16	139	17	83
3 q.	89	13	99	15	109	16	119	18	129	19	139	20	1 q.
9	89	15	99	16	109	17	118	19	128	20	138	22	81
10	89	16	98	17	108	19	118	21	128	23	138	24	80
1 P.	88	18	98	20	108	21	118	23	128	25	137	27	7 P.
12	88	19	98	21	108	23	117	25	127	27	137	29	78
13	88	20	97	22	107	25	117	27	127	29	136	31	77
1 q	87	22	97	24	107	27	116	29	126	31	136	34	3 q.
15	87	23	97	26	106	28	116	31	126	34	135	36	75
16	86	25	96	28	106	30	115	33	125	36	135	39	74
2 q.	86	26	96	29	105	32	115	35	124	38	134	41	2 q.
18	86	28	95	31	105	34	114	37	124	40	134	43	72
19	85	29	95	33	104	36	113	39	123	42	132	46	71
3 q.	85	30	94	34	103	37	113	40	122	44	132	48	1 q.
21	84	32	93	36	103	39	112	43	121	47	131	50	69
2 P.	83	34	92	38	102	42	111	46	120	50	130	54	6 P.
24	82	37	91	41	100	45	110	49	119	53	128	57	66
1 q.	81	38	90	43	99	47	108	51	117	56	126	60	3 q.
26	81	39	90	44	99	48	108	53	117	57	126	61	64
27	80	41	89	45	98	50	107	54	116	58	125	63	63
2 q.	79	42	88	47	97	52	106	56	115	61	124	65	2 q.
29	79	44	87	48	96	53	105	58	114	63	122	68	61
30	78	45	87	50	95	55	104	60	113	65	121	70	60
3 q.	77	46	86	51	94	56	103	62	111	67	120	72	1 q.
32	76	48	85	53	93	58	102	64	110	69	119	75	58
3 P.	75	50	83	56	92	61	100	67	108	72	117	78	5 P.
35	74	52	82	57	90	63	98	69	106	75	115	80	55
1 q.	72	54	80	60	88	66	96	72	104	78	112	84	3 q.
38	71	55	79	62	87	68	94	74	102	80	110	86	52
2 q.	70	57	77	63	85	69	92	76	100	82	108	88	2 q.
41	68	59	75	66	83	72	91	79	98	85	106	91	49
3 q.	67	60	74	67	81	74	89	80	96	87	104	94	1 q.
43	66	61	73	68	80	75	88	82	95	89	102	95	47
44	65	62	72	69	79	76	86	83	93	90	101	97	46
4 P.	64	64	71	71	78	78	85	85	92	92	99	99	4 P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

Q

A Traverſe Table.

Co.	15		16		17		18		19		20		Co.
P D	L,	D.	L,	D,	L,	D	L,	D,	L,	D,	L,	D,	P D
1	150	03	160	03	170	03	180	03	190	03	200	04	89
2	150	05	160	06	170	06	180	06	190	07	200	07	88
1 q	150	07	160	08	170	08	180	09	190	09	200	10	3 q.
4	150	10	160	11	170	12	179	13	189	13	199	14	86
2q	149	15	159	16	169	17	179	18	189	19	199	20	2 q.
7	149	18	159	19	169	21	179	22	189	23	198	24	83
3 q.	149	22	159	23	169	25	178	26	188	28	198	29	1 q.
9	148	23	158	25	168	27	178	28	188	30	197	31	81
10	148	26	157	28	167	29	177	31	187	33	197	35	80
1P.	147	29	157	31	167	33	177	35	186	37	196	39	7P.
12	147	31	156	33	166	35	176	37	186	39	196	42	78
13	146	34	156	36	166	38	176	40	185	42	195	45	77
1 q.	146	36	155	39	165	41	175	44	184	46	194	48	3 q.
15	145	39	155	41	164	44	174	47	184	49	193	52	75
16	144	41	154	44	163	47	173	50	183	52	192	55	74
2 q.	143	44	153	47	162	50	172	52	182	55	191	58	2 q.
18	143	46	152	49	162	52	171	56	181	59	190	62	72
19	142	49	151	52	161	55	170	59	180	61	189	65	71
3 q.	141	51	150	54	160	57	169	60	179	64	188	67	1 q.
21	140	54	149	58	159	61	168	64	177	68	187	72	69
2P.	139	58	148	61	157	65	167	69	176	72	185	76	6P.
24	137	61	146	65	155	69	164	73	174	77	183	81	66
1 q.	135	64	145	69	154	73	163	77	172	81	181	86	3 q.
26	135	66	144	70	153	74	162	79	171	83	180	88	64
27	134	68	143	73	151	77	160	82	169	86	178	91	63
2 q.	132	70	141	75	150	79	159	84	168	89	176	94	2 q.
29	131	73	140	77	149	82	157	87	166	92	175	97	61
30	130	75	139	80	147	85	156	90	165	95	174	100	60
3 q.	129	77	137	82	146	87	154	92	163	97	171	103	1 q.
32	127	79	136	85	144	90	153	95	161	101	170	106	58
3 P.	125	83	133	89	142	94	150	100	158	106	166	111	5P.
35	123	86	131	97	139	98	147	103	156	109	164	115	55
1 q.	120	90	128	96	136	102	144	108	152	114	161	119	3 q.
38	118	92	126	98	134	105	142	111	150	117	158	123	52
2 q.	116	94	124	101	132	107	140	113	147	120	155	127	2 q.
41	113	98	121	105	128	111	136	118	143	125	151	131	49
3 q.	111	100	119	107	126	114	134	120	141	127	148	134	1 q.
43	110	102	117	109	124	116	132	123	139	130	146	136	47
44	108	104	115	111	122	118	129	125	137	132	144	139	46
4P.	106	106	113	113	120	120	127	127	134	134	141	141	4P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	21		22		23		24		25		26		Co,
P D	L,	D,	L,	D,	L;	D,	L,	D,	L,	D,	L;	D,	P D
1	210	04	220	04	230	04	240	04	250	04	260	05	89
2	210	07	220	08	230	08	240	08	250	09	260	09	88
1 q.	210	10	220	11	230	11	240	12	250	12	260	13	3 q,
4	209	15	219	15	229	16	239	17	249	17	259	18	86
2 q,	209	21	219	22	229	23	239	24	249	25	259	26	2 q,
7	208	26	218	27	228	28	338	29	248	30	258	32	83
3 q.	208	31	218	32	228	34	238	35	248	37	257	38	1 q,
9	207	33	217	34	227	36	237	38	247	39	257	41	81
10	207	36	217	38	226	40	236	42	246	43	256	45	80
1 P.	206	41	216	43	226	45	236	47	245	49	255	51	7 P,
12	205	44	215	46	225	48	235	50	244	52	254	54	78
13	205	47	214	49	224	52	234	54	243	56	253	58	77
1 q,	204	50	213	53	223	56	233	58	242	60	252	63	3 q.
15	203	54	212	57	222	60	232	62	241	65	251	67	75
16	202	58	211	61	221	64	231	66	240	69	249	72	74
2 q,	201	61	210	64	220	67	230	70	239	73	248	76	2 q.
18	200	65	209	68	219	71	228	73	238	77	247	80	72
19	199	68	208	72	217	75	227	77	236	81	246	85	71
3 q,	197	70	207	74	216	77	226	80	235	84	244	87	1 q.
21	196	75	205	79	215	82	224	86	233	90	243	93	69
2 P,	195	80	204	84	213	88	222	91	231	95	240	99	6 P,
24	192	85	201	89	210	92	219	98	228	102	237	106	66
1 q,	190	90	199	94	208	98	217	103	226	107	235	111	3 q.
26	189	92	198	97	207	101	216	105	225	110	234	114	64
27	187	95	196	100	205	104	214	109	223	113	232	118	63
2 q.	185	98	194	103	203	108	212	112	221	117	230	122	2 q.
29	184	102	192	107	201	111	210	116	219	121	227	126	61
30	182	105	190	110	199	115	208	120	216	125	225	130	60
3 q,	180	108	189	113	197	118	206	123	214	128	223	133	1 q.
32	178	113	186	117	195	122	203	127	212	132	220	138	58
3 P,	175	117	183	122	192	128	200	133	208	139	217	144	5 P.
35	172	120	180	126	188	132	197	138	205	143	213	149	55
1 q,	169	125	177	131	185	137	193	143	201	149	209	155	3 q.
38	165	129	173	135	181	141	189	148	197	154	205	160	52
2 q,	163	133	171	139	179	146	186	153	194	159	202	166	2 q,
41	158	138	166	144	174	151	181	157	189	164	196	171	49
3 q,	156	141	163	148	171	155	178	161	186	168	193	175	1 q,
43	154	143	161	150	168	157	175	164	183	171	190	177	47
44	151	146	158	153	165	160	173	167	180	174	187	181	46
4 P.	148	148	155	155	163	163	170	170	177	177	184	184	4 P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D.	L,	

A Traverse Table.

Co.	27		28		29		30		31		32		Co.
PD	L,	D,	L,	D,	L,	D,	L,	D.	L,	D,	L,	D,	PD
1	270	05	280	05	290	05	300	05	310	05	320	06	89
2	270	09	280	10	290	10	300	11	310	11	320	10	88
1 q.	270	13	280	14	290	14	300	15	310	15	320	16	3 q.
4	269	19	279	20	289	20	299	21	309	22	319	22	86
2 q.	269	27	279	28	289	29	299	29	308	30	318	31	2 q.
7	268	33	278	34	288	35	298	37	308	38	318	39	83
3 q.	267	40	277	41	287	42	297	44	307	46	317	47	1 q.
9	267	42	276	44	286	45	296	47	306	49	316	50	81
10	266	47	276	49	286	50	295	52	305	54	315	55	80
1P.	265	53	275	55	284	57	294	58	304	60	314	62	7P.
12	264	56	274	58	284	60	293	62	303	64	313	66	78
13	263	61	273	63	282	65	292	67	302	70	312	72	77
1 q.	262	65	272	68	281	70	291	73	301	75	310	77	3 q.
15	261	70	270	72	280	75	290	78	299	80	309	83	75
16	259	74	269	77	278	80	288	83	298	85	307	88	74
2 q.	258	79	268	82	277	85	287	87	296	90	306	92	2 q.
18	257	83	266	86	276	90	285	93	295	96	304	100	72
19	255	88	265	91	274	94	284	98	293	101	303	104	71
3 q.	254	90	263	94	272	97	282	101	291	104	301	108	1 q.
21	252	97	261	100	271	104	280	107	289	111	299	115	69
2P.	250	103	259	107	268	111	277	115	286	119	295	123	6P.
24	247	110	256	114	265	118	274	122	283	126	292	130	66
1 q.	244	116	253	120	262	124	271	128	280	133	289	137	3 q.
26	243	118	252	123	261	127	270	131	279	136	288	140	64
27	241	123	249	127	258	132	267	136	276	141	285	145	63
2 q.	238	126	247	131	256	136	265	141	274	145	282	150	2 q.
29	236	131	245	136	254	141	262	145	271	150	280	155	61
30	234	135	242	140	251	145	260	150	268	155	277	160	60
3 q.	231	138	240	143	249	148	257	154	266	159	274	164	1 q.
32	229	143	237	148	246	154	254	159	263	164	271	170	58
3P.	225	150	233	156	241	161	249	167	257	172	265	178	5P.
35	221	155	229	161	238	166	246	172	254	178	262	183	55
1 q.	217	161	225	167	233	173	241	179	249	185	257	191	3 q.
38	213	166	221	172	228	178	236	185	244	191	252	197	52
2 q.	208	172	217	178	225	184	232	190	240	196	247	203	2 q.
41	204	177	211	184	219	190	226	197	234	203	241	210	49
3 q.	201	181	207	188	215	195	222	201	230	208	237	215	1 q.
43	197	184	205	191	212	198	219	205	226	211	234	218	47
44	194	188	201	194	209	201	216	208	223	215	230	222	46
4P.	191	191	198	198	205	205	212	212	219	219	226	226	4P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	33		34		35		36		37		38		Co.
PD	L,	D,	L,	D,	L,	D,	L,	D,	L	D,	L,	D,	PD
1	330	06	340	06	350	06	360	06	370	07	380	07	89
2	330	12	340	12	350	12	360	13	370	13	380	13	88
1 q.	330	16	340	17	350	17	360	18	370	18	380	19	3 q.
4	329	23	339	24	349	24	359	25	369	26	379	27	86
2 q.	328	32	338	33	348	34	358	35	368	36	378	37	2 q.
7	327	40	337	41	347	4	357	44	367	45	377	46	83
3 q.	327	49	337	50	346	52	356	53	366	55	376	56	1 q.
9	326	52	336	53	346	55	355	56	365	58	375	60	81
10	325	57	335	59	345	61	354	62	364	64	374	66	80
1 P,	324	64	333	66	343	68	353	70	363	72	373	74	7 P.
12	323	69	332	71	342	73	352	75	362	77	372	79	7
13	321	74	331	76	341	79	351	81	360	83	370	85	77
1 q.	320	80	330	82	340	85	349	87	359	90	369	92	3 q.
15	319	85	328	88	338	90	348	93	357	96	367	98	75
16	317	91	327	94	336	96	346	99	356	102	365	105	74
2 q.	316	95	325	98	335	101	344	104	354	107	363	110	2 q.
18	314	102	323	105	333	108	342	111	352	114	361	117	72
19	312	107	321	111	331	114	340	117	350	121	359	124	71
3 q.	310	111	319	114	329	118	338	121	348	124	357	128	1 q.
21	308	118	317	122	327	125	336	129	345	133	355	136	69
2 P.	305	127	314	131	323	135	332	138	341	142	350	146	6 P,
24	301	134	311	138	320	142	329	147	338	151	347	155	66
1 q.	298	141	307	146	316	150	325	154	334	158	343	163	3 q.
26	297	144	306	149	315	153	324	158	332	162	341	166	64
27	294	149	303	154	312	159	321	163	330	168	339	172	63
2 q.	291	155	300	159	309	164	318	169	326	174	335	179	2 q.
29	289	160	297	165	306	170	315	174	324	179	332	184	61
30	286	165	295	170	303	175	312	180	320	185	329	190	60
3 q.	283	169	291	174	300	179	309	185	317	190	326	195	1 q.
32	280	175	288	180	297	185	305	19	314	196	322	201	58
3 P.	273	183	282	189	291	194	299	200	308	206	316	211	5 P.
35	270	189	279	195	287	201	295	206	303	212	311	218	55
1 q.	265	197	273	203	281	209	289	215	297	221	305	227	q.
38	260	203	268	209	276	215	284	222	292	228	299	234	52
2 q.	255	209	262	215	270	22	278	228	286	234	293	24	2 q.
41	249	217	256	223	264	23	272	236	279	243	287	249	49
3 q.	244	221	252	228	259	235	267	241	274	248	281	255	1 q.
43	241	225	249	232	256	239	263	245	270	252	278	259	47
44	237	229	245	236	252	24	259	250	266	256	273	264	46
4 P.	233	233	240	240	247	247	254	254	261	261	269	269	4 P.
	D.	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	39		40		41		42		43		44		Co.
PD	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	PD
1	390	07	400	07	410	07	420	07	430	08	440	08	89
2	390	14	400	14	410	14	420	15	430	15	440	15	88
1 q.	390	19	400	20	409	20	419	21	429	21	439	22	3 q.
4	389	27	399	28	409	29	419	29	429	30	439	31	86
2 q.	388	38	398	39	408	40	418	41	428	42	438	43	2 q.
7	387	48	397	49	407	50	417	51	427	52	437	54	83
3 q.	386	58	396	59	406	61	416	62	425	64	435	65	1 q.
9	385	61	395	63	405	64	415	66	425	67	435	69	81
10	384	68	394	69	404	71	414	73	423	75	433	77	80
1P.	383	76	392	78	402	80	412	82	422	84	432	86	7 P.
12	381	81	391	83	401	85	411	87	421	89	430	91	78
13	380	88	390	90	399	92	409	94	419	97	429	99	77
1 q.	378	94	388	97	398	99	407	102	417	104	427	107	3 q.
15	377	101	386	103	396	106	406	109	415	111	425	114	75
16	375	107	384	110	394	113	404	116	413	118	423	121	74
2 q.	373	113	383	116	392	119	402	122	411	125	421	128	2 q.
18	371	120	380	124	390	127	399	130	409	133	418	136	72
19	369	127	378	130	388	133	397	137	407	140	416	143	71
3 q.	367	131	377	135	386	138	396	141	405	145	414	148	1 q.
21	364	140	373	143	383	147	392	151	401	154	411	158	69
2P.	360	150	369	153	378	157	387	161	396	165	406	169	6 P
24	356	159	365	163	375	167	384	171	393	175	402	179	66
1 q.	352	167	362	171	370	176	379	180	388	184	397	189	3 q.
26	350	171	359	175	368	180	377	184	386	188	395	193	64
27	347	177	356	182	365	186	374	191	383	195	392	200	63
2 q.	344	184	353	189	362	193	371	198	380	203	388	208	2 q.
29	341	189	350	194	358	199	367	204	376	208	385	213	61
30	338	195	346	200	355	205	364	210	372	215	381	220	60
3 q.	334	201	343	206	351	210	360	216	369	221	377	226	1 q.
32	331	207	339	212	348	217	356	223	365	228	373	233	58
3P.	324	217	333	222	341	228	349	233	358	239	366	244	5P.
35	320	223	328	229	336	235	344	241	352	246	360	252	55
1 q.	313	233	321	238	329	244	337	250	345	256	353	262	3 q.
38	307	240	315	246	323	252	331	259	339	265	347	271	52
2 q.	301	247	309	254	316	260	324	266	332	272	340	278	2 q.
41	294	256	302	262	310	269	317	275	325	282	332	289	49
3 q.	289	262	296	269	304	275	311	282	319	289	326	295	1 q.
43	285	266	292	273	300	280	307	286	314	293	321	300	47
44	280	271	288	278	295	285	302	292	309	299	316	306	46
4P.	276	276	283	283	290	290	297	297	304	304	311	311	4P,
	D,	L,	D,	L,	D,	L,	D.	L,	D,	L.	D,	L,	

A Traverſe Table.

Co.	45		46		47		48		49		50		Co.
P D	L,	D.	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	P D
1	450	08	460	08	470	08	480	08	490	09	500	09	89
2	450	16	460	16	470	16	480	17	490	17	500	18	88
1 q	449	22	459	23	469	23	479	24	489	24	499	25	3 q.
4	449	31	459	32	469	33	479	34	489	34	499	35	86
2q	448	44	458	45	468	46	478	47	488	48	498	49	2 q.
7	447	55	457	56	466	57	476	59	486	60	496	61	83
3 q.	445	67	455	68	465	70	475	71	485	72	495	73	1 q.
9	444	70	454	72	464	73	474	75	484	77	494	78	81
10	443	78	453	79	463	81	473	83	483	85	493	87	80
1P.	441	88	451	90	461	92	471	94	481	96	490	98	7P.
12	440	94	450	96	460	98	470	100	479	102	489	104	78
13	438	101	448	103	458	106	467	108	477	110	487	112	77
1 q.	437	109	446	111	456	114	466	116	475	119	485	121	3 q.
15	435	116	444	119	454	122	464	124	473	127	483	129	75
16	432	124	442	127	452	129	461	132	471	135	481	138	74
2 q.	430	130	440	133	449	136	459	139	469	142	478	145	2 q.
18	428	139	437	142	447	145	456	148	466	151	475	154	72
19	426	146	435	150	444	153	454	156	463	159	473	163	71
3 q.	424	151	433	155	443	158	452	161	462	165	471	168	1 q.
21	420	161	429	165	439	167	448	171	457	175	467	179	69
2P.	415	172	424	176	434	180	443	184	452	188	462	191	6P
24	411	183	420	187	429	191	438	195	448	199	457	203	66
1 q.	406	193	416	197	425	201	434	206	443	210	452	214	3 q.
26	404	197	413	202	422	206	431	210	440	215	449	219	64
27	401	204	410	209	419	213	428	218	437	222	445	227	63
2 q.	397	212	406	217	415	222	424	227	432	232	441	236	2 q.
29	393	218	402	223	411	228	420	233	428	237	437	242	61
30	390	225	398	230	407	235	416	240	424	245	433	250	60
3 q.	386	231	394	236	403	242	411	247	420	252	429	257	1 q.
32	381	238	390	244	399	249	407	254	415	260	424	265	58
3 P.	374	250	383	356	391	261	399	267	408	272	416	278	5P.
35	369	258	377	264	385	270	393	276	401	282	410	288	55
1 q.	361	268	369	274	377	280	385	286	393	292	402	297	3 q.
38	355	277	362	283	370	289	378	295	386	302	394	308	52
2 q.	348	284	355	291	363	297	371	303	379	210	387	317	2 q.
41	340	295	347	302	355	308	363	315	370	321	377	328	49
3 q.	234	302	341	309	349	315	356	322	363	329	370	336	1 q.
43	329	307	336	314	344	321	351	327	358	334	366	341	47
44	323	313	331	320	338	326	345	333	352	340	360	347	46
4P.	318	318	325	325	332	332	339	339	346	346	353	353	4P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	51		52		53		54		55		56		Co.
P D	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	P L
1	510	09	520	09	530	09	540	09	550	10	560	10	89
2	510	18	520	18	530	18	540	19	550	19	560	20	88
1 q.	509	25	519	25	529	26	539	26	549	27	559	27	3 q,
4	509	36	519	36	529	37	539	38	549	38	559	39	86
2 q.	507	50	517	51	527	52	537	53	547	54	557	55	2 q,
7	506	62	516	63	526	65	536	66	546	67	556	68	83
3 q.	504	75	514	76	524	78	534	79	544	81	554	82	1 q,
9	504	80	514	81	523	83	533	84	543	86	553	87	81
10	502	88	512	90	522	92	532	94	542	95	551	97	80
1P.	500	99	510	101	520	103	530	105	539	107	549	109	7P,
12	499	106	509	108	518	110	528	112	538	114	548	116	78
13	497	115	507	117	516	119	526	121	536	124	545	126	77
1 q,	495	123	504	126	514	128	524	131	534	133	543	136	3 q.
15	493	132	502	135	512	137	522	140	531	142	541	145	75
16	490	140	499	143	509	146	519	149	529	152	538	154	74
2 q,	488	148	497	151	507	154	516	157	526	160	535	163	2 q.
18	485	158	494	161	504	164	513	167	523	170	533	173	72
19	482	166	492	169	501	173	511	176	520	179	529	182	71
3 q,	480	171	490	175	499	179	508	182	518	185	527	189	1 q.
21	476	183	485	186	495	190	504	193	51[illegible]	197	523	201	69
2P,	471	195	480	199	490	202	499	206	508	210	518	214	6P,
24	466	207	475	211	484	215	493	220	502	224	512	228	66
1 q,	461	218	470	223	479	227	488	231	497	236	506	240	3 q.
26	458	223	467	228	476	232	485	237	494	241	503	245	64
27	454	232	463	236	472	241	481	245	490	250	499	254	63
2 q.	450	241	459	245	468	249	477	254	485	259	494	264	2 q.
29	446	247	455	252	463	257	472	262	481	267	489	271	61
30	442	255	450	260	459	265	468	270	476	275	485	280	60
3 q,	437	262	446	267	454	272	463	277	471	283	480	288	1 q.
32	432	270	441	276	449	281	458	286	466	291	475	297	58
3P,	424	283	433	289	441	294	449	300	457	306	466	311	5P.
35	418	292	426	298	434	304	442	310	451	315	459	321	55
1 q,	410	304	418	310	426	316	434	322	442	328	450	334	3 q.
38	402	314	410	320	418	326	425	332	433	339	441	345	52
2 q,	395	323	403	329	411	336	418	343	426	349	434	356	2 q,
41	385	335	392	341	400	348	408	354	415	360	423	367	49
3 q,	378	343	385	350	392	356	400	363	408	370	417	376	1 q,
43	373	348	380	355	388	361	395	368	402	375	410	382	47
44	367	354	374	361	381	368	388	375	396	382	403	389	46
4P.	361	361	368	368	375	375	382	382	389	389	396	396	4P.
	D.	L,	D,	L,	D,	L,	D,	L.	D.	L,	D,	L.	

Co.	57		58		59		60		61		62		Co.
P D	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L.	D,	P L
1	570	10	580	10	590	10	600	10	609	12	620	11	8
2	570	20	580	20	590	21	600	21	609	18	620	22	8
1 q,	569	28	579	28	589	29	599	29	609	29	619	22	3 q,
4	569	40	578	41	588	41	598	42	608	44	619	43	8
2 q,	567	56	577	57	587	58	597	59	607	59	617	61	2 q.
7	566	69	576	71	586	72	595	73	605	74	615	75	8
3 q.	564	84	574	85	583	86	593	88	603	89	613	91	1 q.
9	563	8	573	91	582	92	593	94	602	99	612	97	8
10	561	9	571	101	581	102	591	104	601	106	611	108	80
1P.	559	111	569	113	579	115	588	117	598	118	608	121	7P,
12	558	118	567	121	577	123	587	125	597	122	606	129	78
13	555	128	565	130	575	133	585	135	594	139	604	139	77
1 q,	553	138	563	140	572	143	582	145	592	148	601	151	3 q.
15	551	148	560	150	570	153	580	155	590	157	599	160	75
16	548	157	558	160	567	163	577	165	588	169	596	171	74
2 q,	545	166	554	169	564	171	574	174	584	177	593	180	2 q.
18	542	176	552	179	561	182	571	185	581	187	590	192	72
19	539	186	548	189	558	191	567	195	578	199	586	202	71
3 q,	537	192	546	195	556	199	565	202	574	205	584	209	1 q.
21	532	204	541	208	551	211	560	215	568	222	579	222	69
2P,	527	218	536	222	545	226	554	230	564	233	573	237	6P,
24	521	232	530	236	539	240	548	244	557	248	566	252	66
1 q,	515	244	524	248	533	252	542	256	551	261	560	265	3 q.
26	512	250	521	254	530	259	539	263	548	268	557	272	64
27	508	259	517	263	526	268	535	272	544	275	552	281	63
2 q.	503	268	512	273	520	278	529	283	538	287	547	292	2 q.
29	498	276	507	281	516	286	525	291	533	297	542	301	61
30	494	285	502	290	511	295	520	300	529	305	537	310	60
3 q,	489	29	497	298	506	303	515	308	523	314	532	319	1 q.
32	483	302	492	307	500	313	509	318	514	322	526	329	58
3P,	474	317	483	322	491	328	499	333	507	339	515	344	5P.
35	467	327	475	333	483	338	491	344	497	349	508	356	55
1 q,	458	340	466	346	474	352	482	357	490	363	498	369	3 q.
38	449	351	457	357	465	363	473	369	479	374	489	382	52
2 q,	442	362	450	368	458	374	464	381	471	383	479	393	2 q,
41	430	374	438	381	445	387	453	394	458	397	468	407	49
3 q,	428	383	430	380	438	396	445	403	452	410	459	416	1 q,
43	417	389	424	398	431	402	438	409	444	413	453	423	47
44	410	396	417	403	424	410	432	417	437	422	446	431	46
4.P	403	463	410	410	417	417	424	424	431	431	438	438	4P.
	D.	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table,

Co.	63		64		65		66		67		68		
PD	L,	D,	L,	D,	L.	D,	L,	D.	L,	D.	L,	D,	PD
1	630	11	640	11	650	11	660	11	670	12	680	12	89
2	630	22	640	22	650	23	660	23	670	23	680	24	88
1 q	629	31	639	31	649	32	659	32	669	33	679	33	3 q.
4	628	44	638	45	648	45	258	46	668	47	678	47	86
2 q	627	62	637	63	647	64	657	65	667	66	677	67	2 q.
7	625	77	635	78	645	79	655	80	665	82	675	83	83
3 q.	623	92	633	94	643	95	653	97	663	98	673	100	1 q.
9	622	99	632	100	642	102	652	103	662	105	672	106	81
10	620	109	630	111	640	112	650	114	660	116	670	118	80
1P.	618	123	628	12[illegible]	637	127	647	129	657	131	667	133	7 P.
12	616	131	626	133	636	135	645	137	655	139	665	141	78
13	614	142	624	144	633	146	643	148	653	150	662	153	77
1 q.	611	153	621	156	631	158	640	160	650	163	660	165	3 q.
15	609	163	618	166	628	168	637	171	647	173	657	176	75
16	606	174	615	176	625	179	634	182	644	185	654	187	74
2 q.	603	183	613	186	622	189	632	191	641	194	651	197	2 q,
18	599	195	609	198	618	201	628	204	637	207	647	210	72
19	596	205	605	208	615	212	624	215	633	218	643	221	71
3 q.	593	212	603	216	612	219	621	222	631	226	640	229	1 q
21	588	226	597	229	607	233	616	237	625	240	635	244	69
2P.	582	241	591	245	601	249	610	253	619	256	628	260	6 P.
24	576	256	585	260	594	264	603	268	612	272	621	277	66
1 q.	570	269	579	274	588	278	597	282	606	286	615	291	3 q.
26	566	276	575	281	584	285	593	289	602	294	611	298	64
27	561	286	570	291	579	295	588	300	597	304	606	309	63
2 q.	556	297	564	302	573	306	582	311	591	316	600	320	2 q.
29	551	305	560	310	568	315	577	320	586	325	595	330	61
30	546	315	554	320	563	325	572	330	580	335	589	340	60
3 q.	540	324	549	329	558	334	566	339	575	344	583	350	1 q.
32	534	334	543	339	551	345	560	350	568	355	577	360	58
3P.	524	350	532	356	540	361	549	367	557	372	565	378	5 P.
35	516	361	524	367	532	373	541	379	549	384	557	390	55
1 q.	506	375	514	381	522	387	530	393	538	399	546	405	3 q.
38	496	388	504	394	512	400	520	406	528	413	536	419	52
2 q.	487	400	495	406	502	412	510	419	518	425	526	431	2 q.
41	475	413	483	420	491	426	498	433	506	440	513	446	49
3 q.	467	423	474	430	482	436	489	443	496	450	504	457	1 q,
43	461	430	468	436	475	443	483	450	490	457	497	464	47
44	453	438	460	445	468	451	475	458	482	465	489	472	46
4P.	445	445	453	453	460	460	467	467	474	474	481	481	4P.
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Go.	69		70		71		72		73		74		
PD	L,	D,	L,	D,	L,	D,	L.	D.	L,	D,	L ,	D,	PD
1	690	12	700	12	710	12	720	13	730	13	740	13	89
2	690	24	700	24	710	25	720	25	730	25	740	26	88
1 q	689	34	699	34	709	35	719	35	729	36	739	36	3 q.
4	688	48	698	49	708	50	718	50	728	51	738	52	86
q	687	67	697	68	707	69	717	70	726	71	736	72	2 q.
7	685	84	695	85	705	86	715	88	725	89	734	90	83
3 q.	682	101	692	103	702	104	712	106	722	107	732	108	1 q.
9	681	108	691	109	701	111	711	113	721	114	731	116	81
10	680	120	689	121	699	123	709	125	719	127	729	128	80
1P.	677	135	686	137	696	139	706	140	716	142	726	144	7P.
12	675	144	685	146	694	148	704	150	714	152	724	154	78
13	672	155	682	157	692	160	702	162	711	164	721	166	77
1 q.	669	168	679	170	689	173	698	175	708	177	718	180	3 q.
15	666	179	676	181	686	184	695	186	705	189	715	192	75
16	663	190	673	193	682	196	692	198	702	201	711	204	74
2 q.	660	200	670	202	679	206	689	209	699	212	708	215	2 q.
18	656	213	666	216	675	219	685	222	694	226	704	229	72
19	652	225	662	228	671	231	681	234	690	238	700	241	71
3 q.	650	232	659	236	668	239	678	242	687	246	697	249	1 q.
21	644	247	653	251	663	254	672	258	681	262	691	265	69
2P.	638	264	647	268	656	272	665	276	675	279	684	283	6P,
24	630	281	639	285	649	289	658	293	667	297	676	301	66
1 q	624	295	633	299	642	30	651	308	660	312	669	316	3 q.
26	620	302	629	307	638	311	647	376	656	320	665	324	64
27	615	313	624	318	633	322	642	327	650	331	659	336	63
2 q.	609	325	617	330	626	335	635	339	644	344	653	349	2 q.
29	603	335	612	339	621	344	630	349	638	354	647	359	61
30	598	345	606	350	615	355	624	360	632	365	641	370	60
3 q.	592	355	600	360	609	365	618	370	626	376	635	380	1 q.
32	585	366	50	371	602	376	611	382	619	387	628	392	58
3 P.	574	383	582	389	590	394	599	400	607	406	615	411	5 P.
35	565	396	573	401	581	407	590	413	598	419	606	424	55
1 q	554	411	562	417	570	423	578	429	586	435	594	441	3 q.
38	544	425	552	431	559	437	567	443	575	449	583	456	52
2 q.	533	438	541	444	549	450	556	457	564	463	572	469	2 q
41	521	453	528	459	536	466	543	472	551	479	558	485	49
3 q.	511	463	519	470	526	477	533	483	541	490	548	497	1 q.
43	505	471	512	477	519	484	527	491	534	498	541	505	47
44	496	479	504	486	511	493	518	500	525	507	532	514	46
4P	488	488	495	495	502	502	509	509	516	516	523	523	4P.
	D,	L.	D,	L.	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverse Table.

Co.	75		76		77		78		79		80		
PD	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	PD
1	750	13	760	13	770	13	780	14	790	14	800	14	89
2	750	26	760	27	770	27	780	27	790	28	800	28	88
1 q.	749	37	759	37	769	38	779	38	789	39	799	39	3 q.
4	748	52	758	53	768	54	778	54	788	55	798	56	86
2 q.	746	73	756	74	766	75	776	76	786	77	796	78	2 q.
7	745	91	754	93	764	94	774	95	784	96	794	97	83
3 q.	742	110	752	111	762	113	771	114	781	116	791	117	1 q.
9	741	117	751	119	761	120	770	122	780	124	790	125	81
10	739	130	748	132	758	134	768	135	778	137	788	139	80
1 P.	736	146	745	148	755	150	765	152	775	154	785	156	7 P,
12	734	156	743	158	753	160	763	162	773	164	782	166	78
13	731	169	741	171	750	173	760	175	770	178	780	180	77
1 q.	728	182	737	185	747	187	757	190	766	192	776	194	3 q.
15	724	194	734	197	744	199	753	202	763	204	773	207	75
16	721	207	730	209	740	212	750	215	759	218	769	220	74
2 q.	718	218	727	220	737	223	746	220	756	229	766	232	2 q.
18	713	232	723	225	732	238	742	241	751	244	761	247	72
19	709	244	719	247	728	251	737	254	747	257	756	260	71
3 q.	706	253	716	256	725	259	734	263	744	266	753	269	1 q.
21	700	269	709	272	719	276	728	280	737	283	747	287	69
2 P.	693	287	702	291	711	295	721	299	730	302	739	306	6 P,
24	985	305	694	309	703	313	713	317	722	321	731	325	66
1 q.	678	321	687	325	696	329	705	334	714	338	723	342	3 q.
26	674	329	683	333	692	338	701	342	710	346	719	351	64
27	668	341	677	345	686	350	695	354	704	359	713	363	63
2 q.	662	353	670	358	679	363	688	368	697	372	706	377	2 q.
29	656	364	665	368	673	373	682	378	691	38[illegible]	700	388	61
30	650	375	658	380	667	385	675	390	684	395	693	400	60
3 q.	643	386	652	391	660	396	669	401	678	406	686	411	1 q.
32	636	398	644	403	653	408	661	413	670	419	678	424	58
3 P.	624	417	632	422	640	428	648	433	657	439	665	44[illegible]	5 P.
35	614	430	622	436	631	442	639	447	647	453	655	459	55
1 q.	602	447	610	453	618	459	626	465	634	471	642	477	3 q.
38	591	462	599	468	607	474	615	480	622	486	630	493	52
2 q.	580	476	587	482	595	488	603	495	611	501	618	507	2 q.
41	566	492	574	499	581	505	589	512	596	518	604	525	49
3 q.	556	504	563	501	570	517	578	524	585	530	593	537	1 q.
43	549	512	556	518	563	525	570	532	578	539	585	545	47
44	539	521	547	528	554	535	561	542	568	549	575	556	46
4 P.	530	530	537	537	544	544	552	552	559	559	566	566	4 P.
	D,	L,	D,	L,	D,	L,	D.	L,	D,	L,	D,	L,	

Co.	81		82		83		84		85		86		P D
PD	L.	D.	L.	D.	L.	D.	L.	D.	L.	D.	L.	D.	Co.
1	810	14	820	14	830	14	840	15	850	15	860	15	89
2	810	28	819	29	829	29	839	29	849	30	859	30	88
1q.	809	40	819	40	829	41	839	41	849	42	859	42	3.
4	808	57	818	57	828	58	838	59	848	59	858	60	86
2q.	806	79	816	80	826	81	836	82	846	83	856	84	2q.
7	804	99	814	100	824	101	834	102	844	104	854	105	83
3q.	801	119	811	120	821	122	831	123	841	125	851	126	1q.
9	800	127	810	128	820	130	830	131	840	133	849	135	81
10	798	140	808	142	817	144	827	146	837	147	847	149	80
1P.	794	158	804	160	814	162	824	164	834	166	844	168	7P.
12	792	168	802	171	812	173	822	175	831	177	841	179	78
13	789	182	799	184	809	187	818	189	828	191	838	193	77
1q.	786	197	795	199	805	202	815	204	825	206	835	209	3q.
15	782	210	792	212	802	215	811	227	821	220	831	223	75
16	779	223	788	226	798	229	807	231	817	234	827	237	74
2q.	775	235	785	238	794	241	804	248	813	247	823	249	2q.
18	770	250	780	253	789	256	799	260	808	263	818	266	72
19	766	264	775	267	785	270	796	274	804	277	813	286	71
3q.	763	273	772	276	781	280	791	283	800	286	810	290	1q.
21	756	290	765	294	775	297	784	301	793	305	803	308	69
2P.	748	310	758	314	767	318	776	321	785	325	795	329	6P.
24	740	329	749	333	758	338	767	342	776	346	786	350	66
1q.	731	346	741	351	750	355	759	359	768	363	777	368	3q.
26	728	355	737	359	746	364	755	368	764	373	773	377	64
27	722	368	731	372	740	377	748	381	757	386	766	390	63
2q.	714	382	723	386	732	391	741	396	750	401	759	405	2q.
29	708	393	717	398	726	402	735	407	743	412	752	417	61
30	701	405	710	410	719	415	727	420	736	425	745	430	60
3q.	695	416	703	421	712	427	720	432	729	437	738	442	1q.
32	687	429	695	435	704	440	712	445	721	451	729	456	58
3P.	673	450	682	456	690	461	698	467	700	472	715	478	5P.
35	663	465	672	470	680	476	688	482	696	487	704	493	55
1q.	650	483	658	489	667	494	675	500	683	506	691	512	3q.
38	638	499	646	595	654	511	662	517	670	523	678	530	52
2q.	626	514	634	520	641	526	649	533	657	539	665	546	2q.
41	611	531	619	538	626	544	634	551	642	558	649	564	49
3q.	600	544	607	551	615	557	622	564	630	571	637	577	1q.
43	592	552	600	559	607	566	614	573	622	580	629	586	47
44	583	563	590	570	604	583	611	590	619	597	619	597	46
4P.	573	573	580	580	587	587	594	594	601	601	608	608	4P.
		D,	L,	D.	L,	D,	L,	D,	L,	D,	L,	D,	L.

Co.	87		88		89		90		91		92		Co,
PD	L,	D,	L	D,	L	D,	L	D,	L,	D,	L,	D,	PD
1	870	15	880	15	890	16	900	16	910	16	920	16	89
2	869	30	879	31	889	31	899	31	909	32	919	32	88
1 q.	869	42	879	43	889	44	899	44	909	45	919	45	3 q.
4	868	62	878	61	888	62	898	63	908	64	918	64	86
2 q.	866	85	876	86	886	87	896	88	906	89	916	90	2 q,
7	863	106	873	107	883	108	893	110	903	111	913	112	83
3 q.	861	128	870	129	880	131	890	132	900	133	910	135	1 q,
9	859	136	869	138	879	139	889	141	899	142	909	144	81
10	857	151	867	153	876	154	886	156	896	158	906	160	80
1 P.	853	170	863	172	873	174	883	176	892	178	902	180	7 P,
12	851	181	861	183	870	185	880	187	890	189	900	191	78
13	848	196	857	198	867	200	877	202	887	205	896	207	77
1 q.	844	211	854	214	863	216	873	219	883	221	892	224	3 q.
15	840	225	850	228	860	230	869	233	879	236	889	238	75
16	836	240	846	243	855	245	865	248	875	251	884	254	74
2 q.	833	252	842	255	852	258	861	261	871	264	880	267	2 q.
18	827	269	837	272	846	275	856	278	865	281	875	284	72
19	823	283	832	287	841	290	851	293	860	296	870	300	71
3 q.	819	293	829	296	838	300	847	303	857	306	866	310	1 q.
21	812	312	821	315	831	319	840	323	849	326	859	330	69
2 P.	804	333	813	337	822	341	832	344	841	348	850	352	6 P,
24	795	354	804	358	813	362	822	366	831	370	840	374	66
1 q.	786	372	796	376	805	381	814	385	823	389	832	393	3 q.
26	782	381	791	386	800	390	809	395	818	399	827	403	64
27	775	395	784	400	793	404	802	409	811	403	820	418	63
2 q.	767	410	776	415	785	419	794	424	803	429	811	434	2 q.
29	761	422	760	427	778	431	787	436	796	441	805	446	61
30	753	435	762	440	771	445	779	450	788	455	797	460	60
3 q.	746	447	755	452	763	457	772	463	781	468	789	473	1 q.
32	738	461	746	466	755	472	763	477	772	482	780	488	58
3 P,	723	483	732	489	740	494	748	500	757	506	765	511	5 P.
35	713	499	721	505	729	510	737	516	745	522	753	528	55
1 q.	699	518	707	524	715	530	723	536	731	542	739	548	3 q.
38	685	536	693	542	701	548	709	554	717	460	725	566	52
2 q.	672	552	680	558	686	564	696	571	703	577	711	583	2 q,
41	657	571	664	579	672	584	679	590	687	607	694	604	49
3 q.	645	584	652	591	659	598	667	604	674	611	682	618	1 q.
43	636	593	644	600	651	607	658	614	666	621	673	627	47
44	626	604	633	611	640	618	647	625	655	632	662	639	46
4 P.	615	615	622	622	629	629	636	636	643	643	651	651	4 P.
	D.	L.	D,	L.	D,	L,	D.	L,	D.	L,	D,	L,	

Co.	93		94		95		96		97		98		Co.
P D	L,	D,	L.	D,	L,	D,	L.	D.	L,	D,	L,	D.	P D
1	930	16	940	16	950	17	960	17	970	17	980	17	89
2	929	32	939	33	949	33	959	34	969	34	979	34	88
1 q.	929	46	939	46	949	47	959	47	969	48	979	48	3 q.
4	928	65	938	65	948	66	958	67	968	68	978	68	86
2 q.	926	91	935	92	945	93	955	94	965	95	975	96	2 q.
7	923	113	933	115	943	116	953	117	963	118	973	119	83
3 q.	920	136	930	138	940	139	950	141	959	142	969	144	1 q.
9	919	145	928	147	938	149	948	150	958	152	968	153	81
10	916	161	926	163	936	165	945	166	955	168	965	170	80
1 P.	912	181	922	183	932	185	941	187	951	189	961	191	7 P.
12	910	193	919	196	929	198	939	200	949	202	958	204	78
13	906	209	916	211	924	214	935	216	945	218	955	220	77
1 q.	902	226	912	228	922	231	931	233	941	236	951	238	3 q.
15	898	241	908	243	918	246	927	248	937	251	947	254	75
16	894	256	903	259	913	262	923	265	932	267	942	270	74
2 q.	890	270	900	273	909	276	919	278	928	281	938	284	2 q.
18	884	287	894	290	903	294	913	297	922	300	932	303	72
19	879	303	889	306	898	309	908	313	917	316	927	319	71
3 q.	876	313	885	317	894	320	904	323	913	327	923	330	1 q.
21	868	333	877	337	887	340	896	344	905	348	915	351	69
2 P.	859	356	869	360	878	364	887	367	896	371	906	375	6 P.
24	850	378	859	382	868	386	877	390	886	394	895	399	66
1 q.	841	398	850	402	859	406	868	410	877	415	886	419	3 q.
26	836	408	845	412	854	416	863	421	872	425	881	430	64
27	829	422	838	427	846	431	855	436	864	440	873	445	63
2 q.	820	438	829	443	838	448	847	452	856	457	864	462	2 q.
29	813	451	822	456	831	461	840	465	848	470	857	475	61
30	806	465	814	470	823	475	831	480	840	485	849	490	60
3 q.	798	478	806	483	815	488	823	493	832	499	841	504	1 q.
32	789	493	797	498	806	504	814	509	82	514	831	519	58
3 P,	773	517	781	522	790	528	798	533	806	539	815	544	5 P.
35	762	533	770	539	778	545	786	551	794	556	803	562	55
1 q,	747	554	755	560	763	566	771	572	779	578	785	584	3 q,
38	733	573	741	579	749	585	756	591	764	597	772	603	52
2 q,	719	590	726	596	734	602	742	609	750	615	757	621	2 q,
41	702	610	709	617	717	623	725	630	732	636	740	643	49
3 q,	689	624	696	631	704	638	711	645	719	651	726	658	1 q,
43	680	634	687	641	695	648	702	655	709	662	717	668	47
34	669	646	676	653	683	660	691	667	6 8	674	705	681	46
4 P.	658	658	665	665	672	672	679	679	686	686	693	693	4 P.
	D,	L,	D.	L,	D,	L.	D,	L,	D,	L,	D.	L,	

Co.	99		100		101		102		103		Co.
P D	L.	D.	L,	D,	L,	D,	L,	D,	L.	D.	P D
1	990	17	1000	17	1010	18	1020	18	1030	18	89
2	989	35	999	35	1009	35	1019	36	1029	36	88
1 q.	989	49	999	49	1009	50	1019	50	1029	51	3 q.
4	986	69	998	70	1008	70	1018	71	1028	72	86
2 q.	985	97	995	98	1005	99	1015	100	1025	101	2 q.
7	983	121	993	122	1002	123	1012	124	1022	125	83
3 q.	979	145	989	147	999	148	1009	150	1019	151	1 q.
9	978	155	988	156	998	158	1007	160	1017	161	81
10	975	172	985	173	995	175	1004	177	1014	179	80
1 P.	971	193	981	195	991	197	1000	199	1010	201	7 P,
12	968	206	978	208	988	210	998	212	1007	214	78
13	965	223	974	225	984	227	994	229	1004	232	77
1 q.	960	241	970	243	980	245	989	248	999	250	3 q.
15	956	256	966	259	978	261	985	264	995	267	75
16	952	273	961	276	971	278	980	281	990	284	74
2 q.	947	287	957	290	967	293	976	296	986	299	2 q.
18	941	306	951	309	961	312	970	315	980	318	72
19	936	322	945	326	955	329	964	332	974	335	71
3 q.	932	333	942	337	951	340	960	344	970	347	1 q.
21	924	356	934	358	942	362	953	366	962	369	69
2 P.	915	379	924	383	933	387	942	390	952	394	6 P,
24	904	403	914	407	923	411	932	415	941	419	66
1 q.	895	423	904	428	913	432	922	436	931	440	3 q.
26	890	434	899	438	908	443	917	447	926	452	64
27	882	449	891	454	900	459	909	463	918	468	63
2 q.	873	466	882	471	891	476	900	481	908	485	2 q.
29	866	480	875	485	883	490	892	494	901	499	61
30	857	495	866	500	875	505	883	510	892	515	60
3 q.	849	503	858	514	866	519	875	524	883	529	1 q.
32	840	525	848	530	856	535	865	541	873	546	58
3 P.	823	550	831	556	840	561	848	567	856	572	5 P.
35	811	568	819	574	827	579	835	585	844	591	55
1 q.	795	590	803	596	811	602	819	608	827	614	3 q.
38	780	610	788	616	796	622	804	628	812	634	52
2 q.	765	628	773	634	781	640	788	647	796	653	2 q.
41	747	649	755	656	762	663	770	669	777	676	49
3 q.	733	665	741	671	748	678	756	685	763	692	1 q.
43	724	675	731	682	739	689	746	695	753	702	47
44	712	688	719	695	726	702	734	708	741	715	46
4 P.	700	700	707	707	714	714	721	721	728	728	4 P,
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	104		105		106		107		108		Co
P D	L,	D,	L,	D,	L,	D,	L,	D,	L,	D,	P D
1	1040	18	1050	18	1060	18	1070	19	1080	19	89
2	1039	36	1049	37	1059	37	1069	37	1079	38	88
1 q.	1039	51	1049	52	1059	52	1069	53	1079	53	3 q.
4	1038	72	1047	73	1057	74	1067	75	1077	75	86
2 q.	1035	102	1045	103	1055	104	1065	105	1075	106	2 q,
7	1032	127	1042	128	1052	129	1062	130	1072	131	83
3 q.	1029	153	1039	154	1048	155	1058	157	1068	158	1 q,
9	1027	163	1037	164	1047	166	1057	167	1067	169	81
10	1024	180	1034	182	1044	184	1054	186	1064	18[illegible]	80
1 P	1020	203	1030	205	1040	207	1049	209	1059	211	7 P,
12	1017	216	1027	218	1037	220	1046	223	1056	225	78
13	1013	234	1023	236	1033	238	1043	241	1052	243	77
1 q.	1009	253	1019	255	1028	258	1038	260	1048	262	3 q.
15	1005	269	1014	272	1024	274	1034	277	1043	280	75
16	1000	287	1009	289	1019	292	1028	295	1038	298	74
2 q.	995	302	1005	305	1014	307	1024	310	1034	313	2 q,
18	989	321	999	324	1008	328	1018	331	1027	334	72
19	983	339	993	342	1002	345	1012	348	1021	352	71
3 q.	979	350	989	354	998	357	1007	360	1017	364	1 q,
21	971	373	981	376	990	380	999	383	1009	387	69
2 P.	961	398	970	402	979	406	989	410	998	413	6 P,
24	950	423	959	427	968	431	977	435	987	439	66
1 q.	940	445	949	449	958	453	967	458	976	462	3 q.
26	935	456	944	460	953	465	962	469	971	473	64
27	927	472	936	477	944	481	953	486	962	490	63
2 q.	917	490	926	495	935	499	944	504	953	509	2 q,
29	910	504	918	509	927	514	936	519	945	524	61
30	901	520	909	525	918	530	927	535	935	540	60
3 q.	892	534	901	540	909	545	918	550	926	555	1 q,
32	882	551	890	557	899	562	907	567	916	572	58
3 P.	865	578	873	583	881	589	890	594	898	600	5 P,
35	852	596	860	602	868	608	876	614	885	619	55
1 q.	835	620	843	628	851	631	859	637	867	643	3 q.
38	819	640	827	646	835	653	843	659	851	665	52
2 q.	804	660	811	666	819	672	827	679	835	685	2 q.
41	785	682	792	689	800	695	808	702	815	708	49
3 q.	770	698	778	705	785	712	793	718	800	725	1 q,
43	761	709	768	716	775	723	783	730	790	736	47
44	748	722	755	729	762	736	770	743	777	750	46
4 P.	735	735	742	742	740	749	757	757	764	764	4 P
	D,	L,	D,	L,	D,	L,	D,	L,	D,	L,	

Co.	109		110		111		112		113		Co.
PD	L,	D,	L.	D,	L,	D,	L.	D.	L.	D.	PD
1	1090	19	1100	19	1110	19	1120	19	1130	19	89
2	1089	38	1099	39	1109	39	1119	39	1129	40	88
1 q,	1088	54	1099	54	1109	55	1119	55	1129	55	3 q.
4	1087	76	1097	77	1107	77	1117	78	1127	79	86
2 q,	1085	107	1095	108	1105	109	1115	110	1125	111	2 q.
7	1082	133	1092	134	1102	135	1112	136	1122	138	83
3 q.	1078	160	1088	161	1098	163	1108	164	1118	166	1 q.
9	1077	170	1086	172	1096	174	1106	175	1116	177	81
10	1073	189	1083	191	1093	192	1103	194	1113	196	80
1P.	1069	213	1079	215	1989	217	1098	219	1108	220	7P,
12	1066	227	1076	229	1086	231	1095	233	1105	235	78
13	1062	245	1072	247	1082	250	1091	252	1101	254	77
1 q,	1057	265	1067	267	1077	270	1086	272	1096	275	3 q.
15	1053	282	1062	285	1072	287	1082	290	1091	292	75
16	1048	300	1057	303	1067	306	1076	309	1086	311	74
2 q,	1043	316	1053	319	1062	322	1072	325	1081	328	2 q.
18	1037	337	1046	340	1056	343	1065	346	1075	349	72
19	1031	355	1040	358	1049	361	1059	365	1068	368	71
3 q,	1026	367	1036	370	1045	374	1054	377	1064	381	1 q.
21	1018	391	1027	394	1037	398	1046	401	1055	405	69
2P,	1017	417	1016	421	1026	425	1035	429	1044	432	6P,
24	996	443	1005	447	1014	451	1023	458	1032	460	66
1 q,	985	466	994	476	1003	475	1012	479	1021	483	3 q.
26	980	478	989	482	998	487	1007	491	1016	493	64
27	971	495	980	499	989	504	998	508	1007	513	63
2 q.	961	514	970	518	979	523	988	528	997	531	2 q.
29	953	528	962	533	971	538	986	543	988	548	61
30	944	545	953	550	961	553	970	560	979	565	60
3 q,	935	560	943	565	952	570	961	576	969	581	1 q.
32	924	578	933	583	941	588	950	594	958	599	58
3P,	906	605	914	611	923	617	931	622	939	628	5P.
35	893	625	901	631	909	637	917	642	925	648	55
1 q,	875	649	883	655	891	661	899	667	907	673	3 q,
38	859	671	867	677	875	683	882	690	890	696	52
2 q,	842	691	850	698	858	704	866	710	873	717	2 q.
41	823	715	830	722	838	728	845	735	853	741	49
3 q,	807	732	815	739	822	745	830	752	837	759	1 q,
43	797	743	804	750	812	757	819	764	826	771	47
44	784	757	791	768	798	772	806	778	813	785	46
4P.	771	771	778	778	785	785	792	792	799	799	4P.
	D,	L,	D,	L.	D,	L.	D,	L.	D.	L,	

A Traverſe Table.

Co.	114		115		116		117		118		Co.
P D	L,	D,	L.	D.	L,	D.	L,	D,	L,	D.	P D
1	1140	20	1150	20	1160	20	1170	20	1180	21	89
2	1139	40	1149	40	1159	41	1169	41	1179	41	88
1 q,	1139	56	1149	56	1159	57	1169	57	1179	58	3q,
4	1137	79	1147	80	1157	81	1167	82	1177	83	86
2q,	1135	112	1144	112	1154	113	1164	114	1174	115	2 q,
7	1131	139	1141	140	1151	141	1161	142	1171	144	83
3 q.	1128	167	1137	169	1147	170	1157	172	1167	173	1 q,
9	1126	178	1136	180	1146	181	1156	183	1165	185	81
10	1123	198	1133	199	1142	201	1152	203	1162	205	80
1P,	1118	222	1128	224	1138	226	1147	228	1157	230	7P,
12	1115	237	1125	239	1134	241	1144	243	1154	245	78
13	1111	256	1121	259	1130	261	1140	263	1150	265	77
1 q.	1106	277	1116	279	1125	282	1135	284	1145	287	3 q.
15	1101	295	1111	298	1120	300	1130	303	1140	305	75
16	1096	314	1105	317	1115	320	1125	322	1134	32	74
2 q,	1091	331	1101	334	1110	336	1120	339	1129	342	2 q.
18	1084	352	1091	355	1103	358	1113	362	1122	363	72
19	1078	371	1087	374	1097	378	1106	381	1116	84	71
3 q.	1073	384	1083	387	1092	391	1102	394	1111	397	1 q.
21	1065	409	107	412	1083	416	1093	419	1102	423	69
2P.	1053	436	1063	440	1072	444	1081	448	1090	452	6P,
24	1041	464	1051	468	1060	472	1069	476	1078	480	66
1 q.	1030	487	1039	492	1048	496	1058	500	1067	505	3 q.
26	1025	506	1034	504	1043	509	1052	513	1061	517	64
27	1016	518	1025	522	1034	527	1042	531	1051	536	63
2 q,	1005	537	1014	546	1023	547	1032	511	1041	556	2 q.
29	997	553	1006	558	1015	562	1023	567	1032	572	61
30	987	570	996	575	1005	580	1013	585	1022	590	60
3 q.	978	586	986	591	995	596	1004	601	1012	606	1 q.
32	967	604	975	610	984	615	992	620	1001	625	58
3 P,	948	633	956	639	964	644	973	650	981	655	5P.
35	934	654	942	650	950	665	958	671	966	677	55
1 q,	915	679	924	685	932	691	940	697	948	700	3 q.
38	898	702	906	708	914	714	922	720	930	727	52
2 q,	881	723	889	729	896	736	904	742	912	748	2 q,
41	860	748	868	754	875	761	883	767	891	774	49
3 q,	844	765	852	772	859	779	867	786	874	792	1 q,
43	834	777	841	784	848	790	856	798	863	805	47
44	820	792	827	799	834	806	842	813	849	820	46
4 P.	806	806	813	813	820	820	827	827	834	834	4 P.
	D,	L,	D.	L,	D,	L,	D,	L,	D,	L,	

A Traverſe Table.

Co.	119		120		121		122		123		Co.
PD	L.	D,	L,	D	L,	D.	L,	D.	L,	D,	D P
1	1190	21	1200	21	1210	21	1219	38	1229	38	89
2	1189	42	1199	42	1209	42	1219	43	1229	43	88
1 q.	1189	58	1199	59	1209	59	1218	60	1228	60	3 q.
4	1187	83	1197	84	1207	84	1217	85	1227	86	86
2 q.	1184	116	1194	117	1204	118	1214	119	1224	120	2 q.
7	1181	145	1191	146	1201	147	1211	149	1221	150	83
3 q.	1177	176	1187	176	1197	177	1207	179	1217	180	1 q.
9	1175	186	1185	188	1195	189	1205	191	1215	192	81
10	1172	206	1182	208	1192	210	1201	212	1211	213	80
1 P.	1167	232	1177	234	1187	236	1196	238	1206	240	7 P.
12	1164	248	1174	250	1183	252	1193	254	1203	256	78
13	1160	269	1169	270	1179	272	1189	274	1198	277	77
1 q.	1154	289	1164	292	1174	294	1183	296	1193	299	3 q.
15	1149	308	1159	311	1169	313	1178	316	1188	318	75
16	1144	328	1153	331	1163	333	1173	336	1182	339	74
2 q.	1139	345	1148	348	1158	351	1168	354	1177	357	2 q.
18	1132	368	1141	371	1151	377	1160	377	1170	380	72
19	1125	387	1135	391	1141	394	1153	397	1163	400	71
3 q.	1120	401	1130	404	1139	408	1149	411	1158	414	1 q.
21	1111	426	1121	430	1130	434	1139	437	1149	441	69
2 P.	1099	455	1116	463	1127	467	1127	467	1136	471	6 P.
24	1087	484	1096	488	1105	492	1114	496	1124	500	66
1 q.	1076	509	1085	513	1093	517	1103	522	1112	526	3 q.
26	1070	522	1079	526	1088	530	1097	535	1106	539	64
27	1060	540	1069	545	1078	549	1087	554	1096	558	63
2 q.	1050	561	1058	565	1067	570	1076	575	1085	580	2 q.
29	1041	577	1050	582	1058	587	1067	591	1076	596	61
30	1031	595	1039	600	1048	605	1057	610	1065	615	60
3 q.	1021	612	1029	617	1038	622	1046	627	1055	632	1 q.
32	1009	631	1018	636	1026	631	1035	647	1043	652	58
3 P.	989	661	998	667	1006	672	1014	678	1023	683	5 P.
35	975	682	983	688	991	694	999	700	1007	705	55
1 q.	956	709	964	715	972	721	980	727	988	733	3 q.
38	938	733	945	739	953	745	961	751	969	757	52
2 q.	920	755	927	761	935	767	943	774	951	789	2 q.
41	898	781	906	787	913	794	921	800	928	807	49
3 q.	882	799	889	805	896	812	905	819	911	826	1 q.
43	870	812	878	818	885	825	892	832	900	839	47
44	856	827	863	834	870	840	878	847	885	854	46
4 P.	841	841	848	848	856	856	863	863	870	870	4 P.
	D,	L,	D,	L.	D,	L,	D,	L.	D,	L,	

A table of numbers for finding more eaſily, the courſe

Diſt. and Dep.				Diſt. and di. of la.				Di. of lat. and deP			
	Co.		Co.		Co.		Co.		Co		Co.
N.	PD	N.	DP	N.	PD	N,	PD	N.	PD	N,	PD
17	1	1000	89	1000	1	17	89	2	1	5882	89
35	2	999	88	999	2	35	88	3	2	2850	88
49	1 q,	999	3 q.	999	1 q.	49	3 q.	5	1 q.	2028	3 q,
70	4	997	86	997	4	70	86	7	4	1435	86
98	2 q,	995	2 q,	995	2 q.	98	2 q,	10	2 q.	1015	2 q,
122	7	993	83	993	7	122	83	12	7	816	83
147	3 q.	989	1 q,	989	3 q.	147	1 q,	15	3 q.	673	1 q,
156	9	988	81	988	9	156	81	16	9	632	81
173	10	985	80	985	10	173	80	18	10	568	80
195	1 P.	981	7 P.	981	1 P	195	7 P,	20	1 P.	500	7 P,
208	12	978	78	978	12	208	78	21	12	470	78
225	13	974	77	974	13	225	77	23	13	433	77
243	1 q,	976	3 q,	970	1 q.	243	3 q.	25	1 q.	398	3 q.
259	15	966	75	966	15	259	75	27	15	373	75
276	16	961	74	961	16	276	74	29	16	349	74
290	2 q,	957	2 q.	957	2 q.	290	2 q,	30	2 q.	330	2 q.
309	18	951	72	951	18	309	72	32	18	308	72
326	19	945	71	945	19	326	71	34	19	290	71
337	3 q,	942	1 q.	942	3 q.	337	1 q,	36	3 q.	281	1 q.
358	21	934	69	934	21	358	69	38	21	260	69
383	2 P,	924	6 P.	924	2 P.	383	6 P,	41	2 P.	240	6 P,
407	24	914	66	914	24	407	66	45	24	225	66
428	1 q,	904	3 q.	904	1 q.	428	3 q.	47	1 q.	212	3 q.
438	26	899	64	899	26	438	64	49	26	205	64
454	27	891	63	891	27	454	63	51	27	196	63
471	2 q.	882	2 q.	882	2 q.	471	2 q,	53	2 q.	187	2 q.
485	29	875	61	875	29	485	61	55	29	180	61
500	30	866	60	866	30	500	60	58	30	173	60
514	3 q.	858	1 q.	858	3 q.	514	1 q,	60	3 q.	168	1 q.
530	32	848	58	848	32	530	58	62	32	160	58
556	3 P.	831	5 P.	831	3 P.	556	5 P.	67	3 P.	150	5 P.
574	35	819	55	819	35	574	55	70	35	143	55
596	1 q,	803	3 q,	803	1 q.	596	3 q.	74	1 q.	136	3 q.
616	38	788	52	788	38	616	52	78	38	128	52
634	2 q,	773	2 q,	773	2 q.	634	2 q.	82	2 q.	123	2 q,
656	41	755	49	755	41	656	49	87	41	115	49
671	3 q,	741	1 q,	741	3 q.	671	1 q,	90	3 q,	110	1 q,
682	43	731	47	731	43	682	47	93	43	107	47
695	44	719	46	719	44	695	46	96	44	103	46
707	4 P.	704	4 P.	707	4 P.	707	4 P.	100	4 P,	100	4 P.

A Table of Natural Sines, Co Sines, Tangents, and Co Tangents to Radius 1.

D M	Si	C S	Ta.	C T	D M	D M	Si.	C S	Ta	C T	D M
0	000	1,0				9	156	997	158	6,31	81
15	004	99	004	229,	45	15	61	87	68	14	45
30	08	9	8	114,	30	30	5	6	7	5 97	30
45	13	9	13	76,4	15	45	9	6	72	82	15
1 d.	17	999	17	57 3	89	10	174	985	176	67	80
15	22	9	022	45 8	45	15	8	4	81	53	45
30	26	9	6	38 2	30	30	82	3	5	44	30
45	31	9	31	32 7	15	45	7	2	00	27	15
2	35	999	35	28,6	88	11	91	2	4	5,14	79
15	39	9	9	5 5	45	15	5	1	9	03	45
30	44	9	044	2 9	30	30	9	0	203	4 92	30
45	48	8	48	0 7	15	45	204	979	8	81	15
3	52	8	52	19 1	87	12	8	8	13	70	78
15	6	998	6	7 6	45	15	12	7	7	61	45
30	061	8	061	6 3	30	30	6	6	22	51	30
45	5	8	5	5 3	15	45	21	5	6	42	15
4	070	997	70	4,3	86	13	25	4	231	,33	77
15	4	7	4	13 5	45	15	9	3	5	25	45
30	8	7	8	2 7	30	30	33	2	40	17	30
45	83	6	083	2 0	15	45	8	1	5	09	15
5	7	996	7	11 4	85	14	242	0	9	4 01	76
15	091	6	91	0 9	45	15	6	969	54	3 94	45
30	6	5	6	0 4	30	30	50	8	9	87	30
45	100	5	100	9,93	15	45	5	7	263	80	15
6	5	5	5	,51	84	15	9	6	8	,73	75
15	9	994	9	13	45	15	63	5	73	67	45
30	113	4	14	8 78	30	30	7	4	7	61	30
45	7	3	18	45	15	45	271	2	82	55	15
7	122	3	122	14	83	16	6	1	7	3,49	74
15	6	992	7	7 86	45	15	80	0	291	43	45
30	31	1	32	59	30	30	4	959	5	38	30
45	5	1	6	35	15	45	8	8	301	32	15
8	9	990	141	12	82	17	92	6	6	27	73
15	143	89	5	6 90	45	15	7	5	11	22	45
30	8	9	9	79	30	30	301	4	5	17	30
45	152	988	154	6 50	15	45	5	2	320	12	15
D M	C S	Si.	CT	Ta.	D M	D M	C S	Si.	CT	Ta.	D M

A Table of Natural Sines, Co Sines, Tangents, and Co Tangents to Radius 1.

D M	Si.	C S	Ta.	CT	D M	D M	Si	C S	Ta	CT	DM
18	309	951	325	3,08	72	27	454	891	510	1,96	63
15	13	0	30	03	45	15	8	89	5	4	45
30	7	48	5	2 99	30	30	62	7	21	2	30
45	21	7	9	96	15	45	6	5	6	0	15
19	6	6	44	90	71	28	9	3	32	88	62
15	30	4	9	86	45	15	73	1	7	6	45
30	4	3	54	82	30	30	7	79	43	4	30
45	8	1	9	79	15	45	81	7	9	2	15
20	42	0	64	75	70	29	5	5	54	0	61
15	346	938	309	2,71	45	15	9	872	560	1,79	45
30	50	7	74	67	30	30	92	0	6	7	30
45	4	5	9	4	15	45	6	68	72	5	15
21	8	4	84	0	69	30	500	6	7	3	60
15	62	2	9	57	45	15	4	4	83	1	45
30	7	0	9	4	30	30	8	2	0	0	30
45	71	29	9	1	15	45	11	59	95	68	15
22	5	7	40	47	68	31	15	7	601	6	59
15	9	6	9	4	45	15	9	5	7	5	45
30	383	924	414	2,41	30	30	522	853	613	1,63	30
45	7	2	9	38	15	45	6	0	9	2	15
23	91	1	24	6	67	32	30	48	25	0	58
15	5	19	30	3	45	15	4	6	31	58	45
30	9	7	5	0	30	30	7	3	7	7	30
45	403	5	40	27	15	45	41	1	43	5	15
24	7	4	45	5	66	33	5	39	50	4	57
15	411	2	50	2	45	15	8	6	6	3	45
30	5	0	6	19	30	30	52	4	62	1	30
45	419	908	461	2,17	15	45	556	831	665	1,40	15
25	23	6	6	4	65	34	9	29	75	8	56
15	7	4	72	2	45	15	61	7	81	7	45
30	31	3	7	0	30	30	6	4	5	5	30
45	4	1	82	07	15	45	70	2	94	4	15
26	8	899	8	5	64	35	4	19	700	3	55
15	42	7	93	3	45	15	7	7	7	1	45
30	6	5	9	1	30	30	81	4	13	0	30
45	50	3	504	1,98	15	45	4	2	20	39	15
D M	C S	Si.	CT	Ta.	D M	D M	C S	Si.	CT	Ta.	D M

A Table of Natural Sines, Co Sines, Tangents and Co Tangents to Radius 1.

D M	Si.	C S	Ta.	C T	D M	D M	Si.	C S	Ta,	C T	D M
36	588	809	736	1,38	54	40 30	649	760	854	1,17	30
15	91	6	30	6	45	45	53	58	62	6	15
30	5	4	40	5	30	41	6	5	9	5	49
45	8	1	7	4	15	15	9	2	77	4	45
37	602	799	54	3	53	30	63	49	85	3	30
15	5	6	60	2	45	45	6	6	93	2	15
30	9	3	7	0	30	42	9	3	900	1	48
45	12	1	74	29	15	15	72	0	8	0	45
38	6	788	81	8	52	30	6	37	16	09	30
15	619	5	788	1,27	45	45	679	734	24	1,08	15
30	23	3	95	6	30	43	82	1	33	7	47
45	6	0	803	5	15	15	5	28	4	6	45
39	9	77	10	3	51	30	8	5	9	5	30
15	33	4	7	2	45	45	92	2	57	4	15
30	6	2	24	1	30	44	5	19	66	3	46
45	9	69	32	0	15	15	8	6	74	3	45
40	43	6	9	19	50	30	701	3	83	2	30
15	6	3	47	8	45	45	4	0	91	1	15
30	9	0	54	7	30	45	7	07	1,0	1,0	45
D M	C S	Si	CT	Ta.	D M	D M	C S	Si.	CT	Ta,	D M

The explanation of the table.

The Sines and Co-ſines are all decimals expreſſed in tenths, hundred, and thouſand parts of an unit, ſo are all the Tangents under 45 degrees, and the Co-tangents above 45, but Tangents above 45 and Co-tangents under 45 are as expreſſed in this table.

In this table you have the Sines, Co-ſines, Tangents, and Co tangents, to every degree and fourth part of a degree by inſpection; ſupplying the blank places by the next figure or figures above or below, according as the degrees are leſs or more than 45.

Ex. Required the Sine, Co-ſine, Tangent, and Co-tangent, of 26d. 30m. per table againſt 26 30 under ſine is 6 and the blanks are ſupplied by 4 4 above, which make .446 the Sine, alſo under Co ſine ſtands five and over the blanks above are 89 which make .895 the Co-ſine then under Tangent is 9, and over the blanks above are 49, which make .499 the Tangent, and under Co-tangent ſtands 1, alſo over the blanks above are 2,0, which make 2.01 the Co-tangent required.

N. B. For the intermediate minutes the Sines, Tangents, &c. may be found by proportion thus,

As fifteen : the tabular difference : : the minutes propoſed : the propoſed part to be added or ſubtracted as the Sine, &c. is increaſing or decreaſing.

5

A
TABLE
OF
Logarithmic Sines, Tangents, &c. to every Degree, and 5th. Minute of the Quadrant.

To find the Sine, Tangent, &c. of any nnmber of Degrees and minutes in the table.

Rule 1ſt. Find the degrees and minutes, if under 45 on the left if above 45 on the right hand ſide of the page, againſt which under Sine, Tangent, &c. or over Sine, Tangent, &c. ſtands the Sine Tangent, &c. required, prefixing the index, and inſerting the figures over the blanks.

Required the Sine and Tangent of 13*d.* 30*m* ?

Againſt 13d. 30m, under Sine ſtand 818 the figures over the blanks are 36, which with the index make 9,36818 the Sine required.

Alſo under Tangent ſtand 8035 which with the index and figure over the blank make 9.38035 the Tangent required.

To find the Sine, Tangent, &c. of ſuch minutes as are not in the table, as between 5 *and* 10, 10 *and* 15, *&c.* ?

Rule 2d. Find the Sine, Tangent, &c to the next leſs number of degrees and minutes per Rule 1ſt. then, multiply the difference by the minutes wanting, viz. 1, 2, 3, or 4, and add or ſubtract that product, to or from the Sine or Tangent, before found, according as the Sines or Tangents, &c. are increaſing or decreaſing.

THE USE OF THE TABLE.

Ex, 1ſt, Required the Sine, Co ſine, Tangent, and Co-tangent of 19 deg, 23m ?

1ſt. The Sine of 19 20 per Table is	9.51991
The difference 36 × 3 gives to add	108
The Sine of 19d. 23m.	9,52099
2d. The Co-ſine of 19 20 per Table is	9.97479
The difference 4,5 × 3 is 13,5 which ſubtract	13
The Co-ſine of 19 23	9,97466
3d, The Tangent of 19 20 per Table is	9,54511
The difference 41 × 3 = 123 which add	123
The Tangent of 19 23	9,54634
4th, The Co-tangent of 19 20 per Table is	10,45488
The Difference 41 × 3 = 123 which ſubtract	123
The Co-tangent of 19 23	10,45365

Ex, 2d, Required the Sine, Co-ſine, Tangent, and Co-tangent, of the compliment of 19 23 that is 70 37 minutes ?

1ſt, The Sine of 70 35 per Table is	9,97456
The difference 4,5 × 2 gives to add	9
The Sine of 70 37	9.97465
2d, The Co-ſine of 70 35 per Table is	9,52170
Difference 36 × 2 = 72 which ſubtract	72
The Co-ſine of 70 37 minutes	9,62098
3d, The Tangent of 70 35 per Table is	10,45286
Difference 40 × 2 is 80 to ſubtract	80
The Tangent of 70 37	10.45366
4th, The Co-tangent of 70 35 is	9,54713
Difference 40 × 2 is 80 to ſubtract	80
The Co-tangent of 70 37 required	9,54633

FROM 0, to 3 DEGREES.

D M	Sine	Dif.	Co, Si,	D,	Tan,	Dif,	Co.Ta.	D M
D M	*Index 7*		*Index 9*		*Index 7*		*Ind. 12*	D M
5	16269	6021	99999	0	16269	6021	83730	55
10	46372	3476	9	0	46372	3476	53627	50
15	63981	2482	9	0	63982	2482	36017	45
20	76475	1931	9	0	76476	1931	23523	40
25	86166	579	8	,2	86167	1579	13832	35
30	94084	337	8	2	94085	337	05914	30
	Index 8		*Index 9*		*Index 8*		*Ind. 11*	
35	00778	159	7	,2	00781	159	99219	25
40	6577	1122	7	2	6580	1122	3419	20
45	11692	914	6	2	11696	914	88303	15
50	6268	827	5	2	6272	827	3727	10
55	20407	755	4	2	20412	755	79587	5
1	4185	695	99993	.2	4192	695	5807	89
5	7661	43	2	2	7669	43	2330	55
10	30879	599	1	3	30888	599	69111	50
15	3875	60	89	3	3885	60	6114	45
20	6677	27	8	3	6689	27	3310	40
25	9310	497	6	3	9323	497	0676	35
30	41791	6	5	4	41806	69	58193	30
35	4139	44	3	4	4156	44	5843	25
40	6366	23	1	4	6384	23	3615	20
45	8484	04	79	4	8505	04	1494	15
50	50504	386	7	4	50526	386	49473	10
55	2434	70	5	4	2458	70	7541	5
2	4281	54	99973	·5	4308	54	5691	88
5	6074	40	1	5	6082	40	3917	55
10	7756	37	68	5	7787	37	2212	50
15	9394	15	6	5	9428	15	0571	45
20	60973	04	3	5	61009	04	38990	40
25	2496	294	1	5	2535	294	7464	35
30	3967	85	58	6	4009	85	5990	30
35	5391	76	5	6	5435	76	4564	25
40	6768	67	2	6	6818	67	3184	20
45	8104	59	49	6	8154	59	1845	15
50	9399	51	6	6	9452	51	0547	10
55	70657	245	3	6	70713	245	29286	5
3	1880		99940		1939		8060	87
D M	Co, Si.	Dif.	Sine	D,	Co, Ta,	Dif,	Tan,	D M

FROM 87 to 90 DEGREES,

FROM 3 to 6 DEGREES.

	Sine	Dif,	Co, Si,	Di.	Tan.	Dif,	Co,Ta.	
D M	*Index* 8		*Index* 9		*Index* 8		*Ind.* 11	D M
3	71880	238	999940	,6	71939	238	28060	87
5	3068	1	37		3131	32	6868	55
10	4225	25	33		4292	26	5707	50
15	5352	0	30	,7	5422	1	4577	45
20	6451	14	26		6524	15	3475	40
25	7522	09	22		7599	0	2400	35
30	8567	4	18	,8	8648	05	1351	30
35	9588	0	15		9673	1	0326	25
40	80585	194	11		80674	195	19325	20
45	1559	91	06		1652	2	8347	15
50	2512	86	02		2610	87	7389	10
55	3445	2	99898		3547	3	6452	5
4	4358	179	4		84464	180	15535	86
5	5252	6	89	,9	5362	77	4637	55
10	6128	2	5		6243	3	3756	50
15	986	68	0		7106	69	2893	45
20	7828	5	75		7952	6	047	40
25	8654	2	0	1,	8783	3	1216	35
30	9464	159	65		9598	0	0401	30
35	90259	156	0		90398	57	09601	25
40	1040	4	55		1184	5	8815	20
45	807	1	0		956	2	043	15
50	2560	48	45	1,3	2715	49	7284	10
55	3301	45	39		3461	6	6538	5
5	4029	143	99834		94195	144	05804	85
5	745	1	28		916	2	083	55
10	5449	39	3		5626	0	4373	50
15	6142	7	17		6325	38	3674	45
20	824	4	1		7013	5	2986	40
25	7496	2	05		690	3	309	35
30	8157	0	799		8357	1	1642	30
35	808	28	3		9014	29	0985	25
40	9449	6	87	1.3	662	7	337	20
	Index 9		*Index* 9		*Index* 9		*Ind.* 10	
45	00081	4	80		00300	5	99699	15
50	704	3	74		929	4	070	10
55	1318	121	68	1.4	1550	3	8449	5
6	01923		99761		2762		7837	84
D M	Co, Si.	Dif.	Sine	Di.	Co, Ta.	Dif,	Tan,	D M

FROM 84 to 87 DEGREES,

FROM 6 to 9 DEGREES,

	Sine		Co,.Si.		Tan,		Co,Ta,	
D M	*Index* 9	Dif,	*Index* 9	Di	*Index* 0	Dif,	*Ind.* 10	D M
6	01923	119	99761	1,4	02162	121	97837	84
5	2520	8	54		765	119	234	55
10	3108	6	47		3360	8	6639	50
15	3689	5	1	1.5	948	6	051	45
20	4262	3	34		4528	4	5471	40
25	827	2	27		5100	3	4899	35
30	5385	0	19		665	1	334	30
35	936	08	12		6225	0	3775	25
40	6480	7	05		775	109	224	20
45	7017	6	697		7319	8	2680	15
50	547	5	0	1,6	851	7	142	10
55	8071	4	82		8389	6	1610	5
7	08589	103	99677		08914	4	91085	83
5	9100	1	67		9433	3	0566	55
10	606	0	59		946	2	053	50
15	10105	99	1		10454	0	89545	45
20	599	8	43		955	99	041	40
25	1087	7	35	1.7	1452	8	8547	35
30	569	5	26		942	7	075	30
35	2046	4	18		2428	6	7571	25
40	518	3	0		908	5	091	20
45	985	2	01	1.8	3383	4	6616	15
50	3447	1	592		854	3	145	10
55	13903	90	84		4319	2	5680	5
8	14355	89	99575	1.8	14780	91	85219	82
5	4802	89	66		5236	90	84763	55
10	5245	8	57		687	89	312	50
15	682	8	48	1.9	6134	8	3865	45
20	6116	7	39		577	8	422	40
25	545	6	29	2,0	7015	7	2984	35
30	970	5	0		449	6	550	30
35	7390	4	10		879	5	120	25
40	807	3	01		8305	5	1694	20
45	8219	2	491		728	4	271	15
50	628	1	81		9146	3	0853	10
55	9032	0	71		560	2	439	5
9	19433		99461	2.0	19971		80028	81
D M	Co, Si.	Dif.	Sine	Di,	Co, Ta.	Dif,	Tan,	D M

FROM 81 to 84 DEGREES,

FROM 9 to 12 DEGREES.

	Sine		Co. Si.		Tang.		Co,Ta.	
D M	*Index* 9	Dif.	*Index* 9	Di	*Index* 9	Di,	*Ind.* 10	D M
9	19433	79	99461	2,	19971	81	80028	81
5	830	9	51		20378	0	79621	55
10	20223	8	41		784	79	218	50
15	613	8	31	2. 1	1181	9	8818	45
20	999	7	21		577	9	422	40
25	1381	6	10		970	8	029	35
30	760	6	00		2360	7	7639	30
35	2136	4	389	2. 2	747	7	252	25
40	250	4	78		3130	6	6869	20
45	878	3	68		510	5	489	15
50	3244	3	57		887	4	112	10
55	607	2	46		4261	4	5738	5
10	23967	71	99335		24631	73	75368	50
5	4323	1	23	2. 3	999	3	000	55
10	677	0	12		5364	3	4635	50
15	5028	0	01		726	2	273	45
20	376	69	289		6086	1	3913	40
25	721	8	78		442	1	557	35
30	6063	8	66	2 4	796	0	203	30
35	402	8	54		7147	0	2852	25
40	736	7	43		496	69	503	20
45	7073	6	31		812	8	157	15
50	404	6	19		8185	8	1814	10
55	733	5	06		526	8	473	5
11	28059	65	99194		28865	68	71134	72
5	383	4	82		9200	7	0798	55
10	704	4	69	2, 5	534	6	465	50
15	9023	3	57		866	5	133	45
20	339	3	44		30195	5	69804	40
25	653	3	32	2, 6	521	5	478	35
30	965	2	19		846	4	153	30
35	30274	2	06		1168	4	8831	25
40	581	1	093		488	4	511	20
45	886	1	80		806	4	198	15
50	1189	0	67		2122	3	7877	10
55	489	59	53	2, 7	435	63	564	5
2	3178[illegible]		99040		32747		252	78
D M	Co, Si.	Dif.	Sine	Di.	Co,Ta.	Di,	Tang,	D M

FROM 78 to 81 DEGREES.

FROM 12 to 15 DEGREES,

	Sine		Co, Si,		Tan,		Co,Ta.	
D M	*Index* 9	Dif,	*Index* 9	Di,	*Index* 9	Dif,	*Ind.* 10	D M
12	31787	59	99040	2.7	32747	63	67252	78
5	2084		26	2,8	3057	2	6942	55
10	378	58	13		364	1	635	50
15	669		8999		673		329	45
20	959	57	85		973		026	40
25	3247		72		4275		5724	35
30	533		58		575	60	424	30
35	817	56	44	2,9	873		126	25
40	4099		29		5169	59	4830	20
45	379	55	15		464		525	15
50	657		01		756	58	243	10
55	934		886		6047		3952	5
13	35208	54	98872	3.0	36336	57	63663	77
5	481		57		623		376	55
10	752		43		909		090	50
15	6031		28		7193	56	2806	45
20	288	53	13		475		524	40
25	554		798		756		243	35
30	818		83	3.1	8035		1964	30
35	7080	52	67		312	55	687	25
40	341		52		588		411	20
45	600	51	37		863	54	136	15
50	875		21		9135		0864	10
55	8113		06		407		592	5
14	38367	50	98690	3,2	39677		60322	76
5	621		74		945	53	054	55
10	871	49	58		40212		59787	50
15	9120		42		477		522	45
20	368		26		741	52	258	40
25	614		10		1004		8995	35
30	859	48	594	3.3	265		731	30
35	40103	48	77		525		474	25
40	345		61		784	51	215	20
45	586	47	44		2041		7958	10
50	825		28		297		702	15
55	1063	47	11	3,4	551	51	448	5
1[illegible]	41299		98494		42805		57194	75
D M	Co. Si.	Dif.	Sine	Di.	Co.Ta,	Dif.	Tan,	D M

FROM 75 to 78 DEGREES,

FROM 15 to 18 DEGREES,

	Sine		Co Si.		Tan,		Co Ta,	
D M	*Index* 9	Dif,	*Index* 9	Di	*Index* 9	Dif,	*Ind*, 1	D M
15	41299	47	98494	3,4	42805	50	57194	75
5	534		77		3057		6942	55
10	768	46	60		308		691	50
15	2000		43		557		442	45
20	231		25		805		194	40
25	461		08	3,5	4052		5947	35
30	689	45	391		298	49	701	30
35	917		73	3.6	543		454	25
40	3142		55		785		212	20
45	367		38		5029		4970	15
50	590		20		270	48	729	10
55	812	44	02		510		489	5
16	44033		98284	3,7	45719		54250	74
5	253	43	66		987	47	012	55
10	471		47	3,8	6224		3775	50
15	689		29		459		540	45
20	905		10		694		305	40
25	5120		192		928		071	35
30	334	42	73	3,9	7160	46	2839	30
35	546		54		391		608	25
40	758		36		622		377	20
45	968		17		851		148	15
50	6178		098		8080	45	1919	10
55	286	41	78		307		692	5
17	46593		98059		48533		51466	73
5	799		40	4.0	759		240	55
10	7004		20		983		016	50
15	208		01		9207	44	0792	45
20	411		7981		429		570	40
25	613	40	61		651		348	35
30	814		41		872		127	30
35	8014		21		50092		49907	25
40	212	39	01		310	43	689	20
45	410		881		528		471	15
50	607		61		746		253	10
51	803		41	4.1	962		037	5
18	48[illegible]8		97820		5117		48820	72
D M	Co Si.	Dif,	Sine	Di	Co Ta.	Dif,	Tan,	D M

FROM 72 to 75 DEGREES,

From 18 to 21 Degrees,

D	M	Sine		Co, Si.		Tan,		Co, Ta,	D	M
D	M	Index 9	Dif,	Index 9	Di	Index 9	Dif,	Ind. 10	D	M
18		48998	39	97820	4.2	51177	43	48822	72	
	5	9192		00		432		607		55
	10	385	38	779		605		394		50
	15	577		58		818	42	181		45
	20	768		37	4.3	2030		7969		40
	25	958		16		241		758		35
	30	50147	37	695		451		548		30
	35	335		74		661		338		25
	40	523		53	4.4	870		129		20
	45	709		31		3078		6921		15
	50	895		10		285		714		10
	55	1080		588		491		508		5
19		51246	37	97567	4.4	53697	41	46302	71	
	5	447	36	45		902		098		55
	10	629		23		4106		5893		50
	15	810		01		309		690		45
	20	991		479	4.5	511		488		40
	25	2170		56		713	40	286		35
	30	349		34		914		085		30
	35	527	35	12		5115		4884		25
	40	704		389		314		685		20
	45	880		67		513		486		15
	50	3056		44		712	39	287		10
	55	231		21	4.6	909		090		5
20		53405	35	97298		56106		43893	70	
	5	578	34	75		302		697		55
	10	750		52		498		501		50
	15	922		29		693		306		45
	20	4093		05		887		112		40
	25	263		182		7080		2919		35
	30	432	33	58		273	38	726		30
	35	601		35	4,7	466		533		25
	40	768		11		657		342		20
	45	936		087		848		151		15
	50	5102		63	4,8	8038		1961		10
	55	268		39		228		771		5
21		55432	33	97015		58417	38	41582	69	
D	M	Co, Si.	Dif,	Sine	Di.	Co, Ta.	Dif.	Tan,	D	M

From 69 to 72 Degrees,

FROM 21 to 24 DEGREES,

	Sine		Co Si.		Tan.		Co Ta.	
D M	Index 9	Dif,	Index 9	Di.	Index 9	Dif,	Ind. 10	D M
21	55432	33	97015	4,9	58417	38	41582	69
5	597		6990		606		393	55
10	760		66		704	37	205	50
15	923		41		981		018	45
20	6085	32	11		9168		0831	40
25	246		892		354		645	35
30	407		67		539		460	30
35	567		42	5,1	724		275	25
40	726		17		900		090	20
45	885		792		60092	36	39907	15
50	7043		67		276		723	10
55	200	31	42	5,2	458		541	5
22	57357	31	96716	5.2	60640	36	39359	68
5	513		691		822		177	55
10	668		65		1003		8996	50
15	823		39		184		815	45
20	977	30	13		364		635	40
25	8131		587		543	35	456	35
30	283		61		722		277	30
35	436		35	5,3	900		099	25
40	587		08		2078		7921	20
45	738		482		256		743	15
50	888		56		432		567	10
55	9038		29		609	35	390	5
23	59187	29	96402	5,4	62785	35	37214	67
5	336		375		960		039	55
10	484		48		3135		6864	50
15	631		21		309		690	45
20	778		294		483	34	516	40
25	924		67	5,5	657		342	35
30	60069		39		830		169	30
35	214		12		4002		5997	25
40	359		184	5,6	174		825	20
45	503		56		346		653	15
50	646		29		517		482	10
51	789	28	01		688	34	311	5
24	60931		96073	5,6	64858		35141	66
D M	Co Si.	Dif,	Sine	Di,	Co Ta.	Dif,	Tan,	D M

FROM 66 to 69 DEGREES,

	Sine		Co Si,		Tan,		Co Ta.	
D M	*Index* 9	Dif,	*Index* 9	Di,	*Index* 9	Dif,	*Ind.* 10	D M
24	60931	28	96075	5,6	64858	34	35141	66
5	61072		044		65028		34972	55
10	213		016	5,7	197		802	50
15	354		95988		366		633	45
20	494		959	5,8	534		465	40
25	633	27	931		702	33	297	35
30	722		902	5.8	870		129	30
35	911	25	95873		66037		33962	25
40	62048		844		204		795	20
45	186		815	5,9	370		629	15
50	322		786		536		463	10
55	459		756		702		297	5
25	594	27	95727	6,	66867	33	33132	65
5	730		698		67031		32968	55
10	864		668		196		803	50
15	998		628		360		639	45
20	63132		608		523		476	40
25	265		578		686	32	313	35
30	398	26	548		849		150	30
35	530		95518	6.	68011	32	31988	25
40	662		488		173		826	20
45	793		457		335		664	15
50	924		427		496		503	10
55	64054	26	396		657		342	5
26	184		95366	6,1	818	32	181	64
5	313		335		978		021	55
10	442		304		69138		30861	50
15	570		273	6,2	297	31	702	45
20	698	25	241		456		543	40
25	825		210	6,3	615		384	35
30	952		179		773		226	30
35	65079	25	95147	6.4	931	31	068	25
40	205		115		70089		29910	20
45	330		084		246		753	10
50	455		052		403		596	15
55	580		020		560		439	5
27	65704	25	94988	6.	70716	31	29283	63
D M	Co Si.	Dif,	Sine	Di.	Co Ta,	Dif,	Tan,	D M

From 27 to 30 Degrees.

		Sine		Co. Si.		Tang.		Co, Ta.		
D	M	Index 9	Dif	Index 9	Di	Index 9	Dif	Index 10	D	M
27		65704	25	94988	6.4	70716	31	29283	63	
	5	828		955	6,5	872		127		55
	10	951		923		71028		28971		50
	15	66074		891	6.6	183		816		45
	20	197	24	858		338		661		40
	25	319		825		493		506		35
	30	440		792		647	31	352		30
	35	66561	24	94759	6.6	71801		28198		25
	40	682		726		955		044		20
	45	802		693		72108		27891		15
	50	922		660	6.7	262	30	737		10
	55	67041		627		414		585		5
28		67160	24	94593	6.8	567	30	432	62	
	5	279		559		719		280		55
	10	397		526		871		128		50
	15	515	23	492		73023		26976		45
	20	632		458	6,9	174		825		40
	25	749		424		325		674		35
	30	67866		389		476		523		30
	35	982	23	94355		626	30	373		25
	40	68098		321	7.	777		222		20
	45	213		286		927		072		15
	50	328		251		74076		25923		10
	55	442	23	216		226		773		5
29		68557	23	94181	7,	375	30	624	61	
	5	670		146		524	25	475		55
	10	784		111		672		327		50
	15	897		076		820		179		45
	20	69009		040		968		031		40
	25	122		005	7.1	75116		24883		35
	30	233	22	93969		264	29	735		30
	35	345		926		411		588		25
	40	456		897	7,2	558		441		20
	45	567	22	861		705		294		15
	50	677		825		851		148		10
	55	787		789		997		002		5
30		69897	22	93753	7,2	76143	29	23856	60	
D	M	Co, Si.	Dif	Sine	Di	Co, Ta,	Dif,	Tang,	D	M

From 60 to 63 Degrees.

FROM 30 to 33 DEGREES,

	Sine		Co Si,		Tan.		Co Ta,	
D M	Index 9	Dif,	Index 9	Di,	Index 9	Dif,	Ind, 10	D M
30	69897	22	93753	7.2	76143	29	23856	60
5	70006		716	7,3	289		710	55
10	115		679		435		564	50
15	223		643	7,4	580	29	419	45
20	331	21	606		725		274	40
25	439		569		870		129	35
30	546		532	7.5	77014		22985	30
35	70653	21	93494		159	29	840	25
40	760		475	7,6	302		697	20
45	866		419		447		552	15
50	972		382		590		409	10
55	71078		344		734	28	265	5
31	183	21	93306	7,6	877		125	59
5	288		268		78020		21979	55
10	393	20	230		163		836	50
15	497		192	7.7	305		694	45
20	601		153		447		552	40
25	705		115	7.8	590		409	35
30	808		076		731	28	268	30
35	911	20	037		873		126	25
40	72013		92998		79015		20984	20
45	116		959	7.9	156		843	15
50	218		920		297		702	10
55	319		881		438	28	561	5
32	72420	20	92842	7,9	578		421	58
5	521		802	8	719		280	55
10	622		762		859		140	50
15	722		723		999		000	45
20	822		683		80139	28	19860	40
25	922		643		279		720	35
30	73021		602	8.1	418		581	30
35	120		92562		558	28	441	25
40	219	19	522	8,1	697		302	20
45	317		481	8,2	836		163	15
50	415		440		974		025	10
55	513		400		81113	27	18886	5
33	73610	19	92359	8,2	81251		18748	57
D M	Co, Si.	Dif,	Sine	Di,	Co Ta.	Dif,	Tan.	D M

FROM 57 to 60 DEGREES,

FROM 33 to 36 DEGREES,

	Sine		Co. Si		Tang,		Co Ta,	
D M	Index 9	Dif.	Index 9	Di,	Index 9	Dif.	Ind. 10	D M
33	73610	19	92359	8.2	81251	27	18748	57
5	707		318		389		610	55
10	804		276	8,3	527		472	50
15	901		235		665		334	45
20	997		194		803		196	40
25	74093		152		941		059	35
30	188	19	110	8.4	82078		17921	30
35	284		068		215	27	784	25
40	379		026		352		647	20
45	473		91984		489		510	15
50	568		9 42		625		374	10
55	662		899		762		237	5
34	74756	19	91857	8,5	898	27	101	56
5	849		814		8 3034		16965	55
10	942		771		170		829	50
15	75035		729		306		693	45
20	128		685		442		557	40
25	220		642		578		421	35
30	312	18	599	8.6	713		286	30
35	75404		91555		848	27	151	25
40	496		512		983		016	20
45	587		468	8,7	84118		15881	15
50	678		424		253		741	10
55	768		380		388		611	5
35	75859	18	91336	8.8	84522	27	15477	55
5	949		292		657		342	55
10	76038		247	8.9	791		208	50
15	128		203		925		074	45
20	217		158		85059		14940	40
25	306		113		193		806	35
30	395		068	9,	326	27	673	30
35	76483	18	023		460		539	25
40	571		90978	9,1	593	26	406	20
45	659		932		727		272	15
50	747	17	887		860		139	10
55	834		841	9,2	993		006	5
36	76921	17	90795		86126	26	13873	54
D M	Co, Si,	Dif.	Sine	Di,	Co Ta.	Dif,	Tang,	D M

FROM 54 to 57 DEGREES,

	Sine		Co Si,		Tang.		Co Ta,	
D M	*Index* 9	Dif,	*Index* 9	Dif.	*Index* 9	Dif,	*Ind,* 10	D M
36	76921	17	90795	9,2	86126	26	13873	54
5	77008		749		258		741	55
10	095		703	9,3	391		608	50
15	181		657		524		475	45
20	267		611		656		343	40
25	353		564	9,4	788		211	35
30	438		517		920		079	30
35	77533	17	90471	9,5	87052	26	12947	25
40	608		424		184		815	20
45	693		377	9,6	316		683	15
50	778		329		448		551	10
55	862		282		579	26	420	5
37	946	17	90234	9.7	711		288	53
5	78030		187		842		157	55
10	113		139		974		025	50
15	196		091		88105		11894	45
20	279		043		236		763	40
25	362		89995		367	26	632	35
30	444	16	946	9'8	498		501	30
35	78528		898		628		371	25
40	608		849		759		240	20
45	690		800		889		110	15
50	772		751		89020		10979	10
55	853		702		150	26	849	5
38	79934	16	89653	9,8	280		719	52
5	014		603	9,9	411		588	55
10	094		554		541		457	50
15	175		504		671		328	45
20	255		454	10,	801		198	40
25	335		404		930		073	35
30	79414	16	354		90660	26	09939	30
35	494		89304	10,	190		809	25
40	573		253	1	319		680	20
45	652		203	10.	449		550	15
50	730		152		578		421	10
55	809		101	10.2	707		292	5
39	79887	16	89050		90836	26	09163	51
D M	Co Si,	Dif,	Sine	Dif.	Co Ta,	Dif.	Tang,	D M

FROM 39 to 42 DEGREES:

	Sine		Co, Si,		Tan.		Co, Ta,	
D M	*Index* 9	Dif,	*Index* 9	Dif,	*Index* 9	Dif,	*Ind.* 10	D M
39.0	79887	16	89050	10,2	90836	26	09163	51
5	965		88999		966		033	55
10	80042		947		91095		08904	50
15	120	15	896		224		775	45
20	198		844	10,3	352		647	40
25	274		792		481		518	35
30	351		740		610		389	30
35	80427		88688	10,4	91739	26	08260	25
40	503	15	636		867		132	20
45	479		583	10,5	996		003	15
50	655		531		92124		07875	10
55	731		478		253		746	5
40.0	80806	15	88425	10,6	92381	26	07618	50
5	881		372		509		490	55
10	956		319	10,7	637		362	50
15	81031		265		765		234	45
20	106		212	10,8	893		106	40
25	180		158		93021		06978	35
30	254		104		149		850	30
35	81328	15	88050		277	25	722	25
40	401		87996	10,9	405		594	20
45	475		941		533		466	15
50	548		887	11,	661		338	10
55	621		832		789		211	5
41.0	81694	14	87777	11,1	93916	25	06083	49
5	766		723		94043		05956	55
10	839		667		171		828	50
15	911		612		298		701	45
20	983		557	11,2	426		573	40
25	82054		501		553	25	446	35
30	126		445		680		319	30
35	197	14	87389	11.2	94809		05191	25
40	268		333		935		064	20
45	339		277		95062		04937	15
50	410		220	11,3	189		810	10
55	480		164		316		682	5
42.0	82551	14	87107	11.4	95443		04556	48
D M	Co, Si,	Dif,	Sine	Dif,	Co. Ta.	Dif,	Tan,	D M

FROM 48 to 51 DEGREES

FROM 42 to 45 DEGREES,

	Sine		Co, Si,		Tan.		Co,Ta,	
D M	*Index* 9	Dif,	*Index* 9	Dif,	*Index* 9	D,	*Ind*, 10	D M
42	82551	14	87107	11,4	95443	25	04556	48
5	621		050		570		429	55
10	690		86993	11,5	697		302	50
15	760		935		824		175	45
20	830		878		951		048	40
25	899		820		96078		03921	35
30	968		763		205		794	30
35	83037	14	86705	11.6	96332	25	667	25
40	105		646		458		541	20
45	174		588		585		414	15
50	242		530	11.7	712		287	10
55	310		471		838		161	5
43	83378	14	86412	11,8	965	25	034	47
5	445		353		97092		02907	55
10	513		294	11,9	218		781	50
15	580		235		345		654	45
20	647		175	12,	471	25	528	40
25	714		116		598		401	35
30	781		056	12,	725		277	30
35	83847	13	85996	12,1	97851	25	02148	25
40	913		935		977		022	20
45	980		875		98104		01895	15
50	84045		815	12,2	230		769	10
55	111		754		357		642	5
44	84177	12,9	85693	12,3	98483	25	01516	46
5	242		632		610		389	55
10	307		571	12.4	736		263	50
15	372		509		862		137	45
20	437	12,8	447		989	25	010	40
25	501		386		99115		00884	35
30	566		324	12.4	241		758	30
35	84630	12,7	85262	12.5	368	25	631	25
40	694		199	12,6	494		505	20
45	758	12.6	137		621		379	15
50	821		074		747		252	10
55	885		011		873	25	126	5
45	84948	12,6	84948	12.6	00000		00000	45
D M	Co, Si,	Dif,	Sine	Dif,	Co.Ta.	D,	Tan.	D M

FROM 45 to 48 DEGREES,

A
TABLE,
Of the Logarithms of Numbers, from 1 to 4000.

1ſt. The Logarithm of any number under 10 is found in the firſt line of the two firſt pages, the Index or Characteriſtic thereof 0 as per table.

2d. The Logarithm of any number under 100 is found in the next 10 lines of the ſaid pages, the Index, &c. 1 as per table.

Example 1ſt, Required the Log. of 73?

Under num, at the top in the firſt column of the left hand page find 7, then under 3 at top againſt 7, is the log, required 86332 which with its index is 1,86332.

Example 2d. Required the Log. of 87?

Under num. at top in the firſt column on the right hand page find 8, then under 7, againſt 8 ſtands 9209 which with the Index and figure above the blank makes 1.89209 the log. required,

To find the Log. of numbers above 100, in the firſt 4 Page,

Rule. Find the units figure at the top of the table, and in that column againſt the other figures at the ſide under num. ſtands the Logarithm or a part thereof, which ſupplyed by the proper Index and figures over the blanks is the log, required.

Example 3d. Required the Log. of 723?

Under 3 at top againſt 72 ſtands 5913, which with the Index 2 and number over the blank 8, makes 2.85913 the log of 723.

Example 4th. Required the Log. of 679?

Under 9 at top againſt 67 at the ſide ſtands 3186, which with the Index 2 and number over the blank 8, makes 2,83186 the logarithm required.

In the laſt 8 Pages, under 1, 2, 3, 4, 5, 6, 7 8, *and* 9, *at the Top are the laſt* 3 *Figures of every Log. In which the Index and other* 2 *Figures muſt be ſupplyed, from the firſt column of Log. in each page under* 0, *as in the following Examples.*

1ſt. the log of 1500 is found in the firſt column of logs. under 0 againſt 150 under num. equal 3,17609. log of 1501 is 3,17638. log. of 1502 is 3.17666. log. of 1503 equal 3,17695. log. of 1504 equal 3.17724. log. of 1505 equal 3.17763. log. of 1506 equal 3.17782. log. of 1507 equal 3.17811. log. of 1508 equal 3.17840. log. of 1509 equal 3.17868.

2d. The log. of 1510 equal 3.17897. log. of 1511 equal 3,17926. log. of 1512 equal 3,17955 log. 1513 equal 3.17983 then for the logarithm of 1514 the figures ſet off in the firſt column of logs. with a parentheſis ſhew, that the 7 over the blank in that line changes to 8 under units 4 at top, whence the log. of 1514 equal 3.18012. and log. of 1515 equal 3.18041 &c. throughout that line.

N. B. The figures in the firſt column under 0 placed thus (9.3) ſhew that the 2 over the blank upwards, changes to 3 under units 9 at the top in that row of Logs. Whence the Log. of 1348 is 3,12968, and the log. of 1349 is 3,13001,

Again, the Log. of 1584 is 3,19975, and the Log. of 1585 is 3,20002. Here the figures (5,20) thus ſet in the firſt column under 0 ſhew that the 19 following the index 3 in the former Log. changes to 20 in that row under units 5 and ſo on throughout that line.

LOGARITHMS of NUMBERS.

Num.	0	1	2	3	4
		0,00000	0.30103	0,47712	0,60206
1	1,00000	1,04139	1.07918	1,11394	1.14612
2	1,30103	32221	34242	36172	38021
3	47712	49136	50515	51851	53147
4	60206	61278	62324	63346	64345
5	69807	70757	71600	72427	73239
6	77815	78532	79239	79934	80618
7	84509	85725	85733	86332	86923
8	90309	90848	91381	91907	92427
9	95424	95904	96378	96848	97312
10	2.00000	2,00432	2,00860	2,01283	2,01703
11	2,04139	2.04532	2.04920	2,05307	2,05690
12	07918	08278	08635	08990	09342
13	11394	11728	12057	12385	12710
14	14613	14921	15228	15533	15836
15	17609	17897	18184	18469	18752
16	20412	19682	20951	21218	21485
17	23045	23299	23552	23804	24054
18	25527	25767	26007	26245	26481
19	27875	28103	28330	28555	28780
20	2,30103	2,30319	2,30535	2.30749	2,30963
21	2,32222	2.32428	2.32633	2,32837	2,33041
22	34242	34439	34635	34830	35024
23	36173	36361	36548	36735	36921
24	38021	38201	38381	38560	38738
25	39794	39967	40140	40312	40483
26	41497	41664	41830	41995	42160
27	43136	43296	43456	43616	43775
28	44716	44870	45024	45178	45331
29	46240	46389	46538	46686	46834
30	2.47712	2.47856	2,48000	2,48144	2,48287
31	2,49136	2.49276	2,49415	2,49554	2,49692
32	50515	50650	50785	50920	51054
33	51851	51982	52113	52244	52374
34	53148	53275	53402	53529	53655
35	54407	54530	54654	54777	54900
36	55630	55750	55870	55990	55610
37	56820	56937	57054	57170	57287
38	57978	58092	58206	58319	58433
39	59106	59216	59328	59439	59549
40	2.60206	60314	60422	60530	60638
41	2,61278	2.61489	2,61384	2.61595	2,61700

Num.	5	6	7	8	9
	0,69897	0,77815	0,84510	0,90309	0,95424
1	1,17609	1,20412	1,23044	1,25527	1,27875
2	39794	41497	43136	44715	46239
3	54406	55630	56820	57978	59106
4	65321	66275	67209	68124	69019
5	74036	74818	75587	76342	77085
6	81291	81954	82607	83250	83884
7	87506	88801	88649	89209	89762
8	92941	93449	93951	94448	94939
9	97772	98227	98677	99122	99564
10	2,02118	2,02530	2,02938	2,03342	2.04139
11	2,06069	2,06445	2,06818	2,07188	2.07554
12	09691	10037	10380	10721	11058
13	13033	13353	13672	13987	14301
14	16139	16435	16731	17026	17318
15	19033	19312	19589	19865	20139
16	21748	22010	22271	22530	22788
17	24304	24551	24797	25042	25285
18	26717	26951	27184	27415	27646
19	29003	29225	29446	29666	29885
20	2,31175	2,31386	2,31597	2.31806	2,32014
21	2.33243	2,33445	2,33645	2,33845	2.34044
22	35218	35410	35602	35793	35983
23	37106	37291	37474	37657	37839
24	38916	39093	39269	39445	39619
25	40654	40824	40993	41161	41329
26	42324	42488	42651	42813	42975
27	43933	44090	44247	44404	44560
28	45484	45636	45788	45939	46089
29	46982	47129	47275	47421	47567
30	2,48420	2,48572	2,48713	2,48855	2,48995
31	2,49831	2,49968	2,50105	2,50242	2.50379
32	51188	51321	51454	51587	51719
33	52504	52633	52762	52891	53019
34	53781	53907	54032	54157	54282
35	55022	55145	55266	55388	55509
36	56229	56348	56466	56584	56702
37	57403	57518	57634	57749	57863
38	58546	58658	58771	58994	59106
39	59659	59769	59879	59988	60097
40	60745	70852	60959	61066	61172
41	2 .61804	2,61909	2,62013	2,62117	2,62221

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42	2,62324	2,62428	2,62531	2,62634	2.62736
43	63346	63447	63548	63648	63748
44	4345	4443	4542	4640	4738
45	5321	5417	5513	5609	5707
46	6275	6275	6464	6558	6651
47	7209	7302	7394	7486	7669
48	8124	8214	8304	8394	8484
49	9019	9108	9196	9284	9372
50	9897	9983	70070	70156	70242
51	2,70757	2.70842	2,70927	2,71011	2.71096
52	2,71600	2.71683	2.71767	2,71850	2,71933
53	2427	2509	2591	2672	2754
54	3239	3319	3479	3559	3639
55	4036	4115	4193	4272	4350
56	4818	4896	4973	5050	5127
57	5587	5663	5739	5815	5891
58	6342	6417	6492	6566	6641
59	7085	7158	7232	7305	7378
60	7815	7887	7959	8031	8103
61	2,78532	2.78604	2.78675	2,78746	2,78816
62	2,79239	2.79309	2,79379	2.79448	2.79518
63	79937	80002	80071	80140	80208
64	80618	0685	0753	0821	0888
65	1291	1358	1424	1491	1557
66	1954	2020	2085	2151	2216
67	2608	2672	2736	2801	2865
68	3250	3314	3378	3442	3505
69	3884	3947	4041	4073	4135
70	4509	4571	4633	4695	4775
71	5125	5184	5248	5308	5369
72	2.85733	2.85793	2,85853	2,85913	2.85973
73	2.86332	2,86391	2,86451	2,86510	2.86569
74	6923	6981	7040	7098	7158
75	7506	7563	7621	7679	7737
76	8081	8138	8195	8252	8309
77	8649	8707	8761	8817	8874
78	9209	9265	9320	9376	9431
79	9762	9817	9872	9927	9982
80	2,90309	2,90363	2.90417	2,90471	2.90525
81	0845	0902	0955	1009	1062
82	1381	1431	1487	1539	1592
83	2,91907	2,91960	2,92012	2.92064	2.92116

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42	2.62838	2,62940	2,63040	2,63144	2,63245
43	3848	3948	4048	4147	4246
44	4836	4933	5030	5127	5224
45	5801	5896	5991	6066	6181
46	6745	6838	6931	7024	7117
47	7669	7760	7851	7842	8033
48	8574	8663	8752	8841	8930
49	9460	9548	9635	9722	9810
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51	2,71181	2,71264	2,71349	2,71432	2,71516
52	2.72015	2.72098	2.72181	2.72263	2,72345
53	2835	2916	2997	3078	3158
54	3639	3719	3798	3957	4036
55	4429	4507	4585	4663	4741
56	5204	5281	5358	5431	5511
57	5966	6042	6117	6192	6267
58	6715	6789	6863	6937	7011
59	7451	7524	7579	7670	7742
60	8175	8247	8318	8390	8461
61	2,78887	2.78958	.79028	2.79098	2,79168
62	2,79588	2,79657	2,79726	2.79795	2.79865
63	80277	80345	80413	80482	80550
64	0955	1023	1090	1175	1224
65	1624	1690	1756	1822	1888
66	2282	2347	2412	2477	2542
67	2930	2994	3058	3122	3186
68	3569	3632	3695	3758	3821
69	4198	4260	4323	4385	4447
70	4818	4880	4941	5003	5064
71	5430	5491	5551	5612	5672
72	2.86033	2,86093	2,86153	2.86213	2.86272
73	2,86628	2,86687	2,86746	2.86805	2,86864
74	7215	7273	7332	7390	7448
75	7794	7852	7909	7966	8024
76	8366	8422	8479	8536	8592
77	8930	8986	9042	9097	9153
78	9486	9542	9579	9652	9707
79	90036	90091	90145	90200	90254
80	0579	0633	0687	0714	0794
81	1115	1169	1222	1275	1328
82	1645	1698	1750	1803	1858
83	2,92168	2.92220	2.92272	2,92324	2,92376

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84		2,92427	479	531	582	634	685	737	788	849	890
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86		3449	500	550	601	615	701	751	801	851	901
87	1,4)	3951	001	051	101	151	200	250	299	349	398
88		4448	497	546	596	645	694	743	792	841	890
89	2,5)	4939	987	036	085	133	182	230	279	327	375
90		5424	472	520	568	616	664	712	760	808	856
91	3,6)	5909	951	999	047	094	142	189	237	284	331
92		6378	425	473	520	567	614	661	707	754	801
93	4,7)	6848	894	941	988	034	081	127	173	220	266
94		2,97313	358	405	452	497	543	589	635	680	720
95	5,8)	7772	818	863	909	954	000	045	091	136	181
96		8228	272	317	362	407	452	497	542	587	632
97	8,9)	8677	721	706	811	855	900	944	989	033	078
98		9122	166	211	255	299	343	387	431	475	519
99		9563	607	651	694	738	782	825	869	913	956
100		3.00000	043	086	130	173	216	259	302	346	389
101		0433	475	518	560	603	646	689	732	774	817
102	4,1)	0863	901	945	987	029	072	114	157	199	241
103		1268	325	367	410	452	494	535	577	619	661
104	8.2)	1703	745	786	828	870	911	953	994	036	077
105		3,02118	160	202	242	284	325	366	407	448	489
106		2530	571	512	653	694	734	775	816	857	897
107	2.3)	2938	978	019	059	100	140	181	221	261	302
108		3342	382	422	462	502	542	582	622	662	702
109	7.4)	3742	782	822	862	901	941	981	020	060	090
110		4139	174	218	275	297	336	375	414	453	493
111		4532	571	610	649	688	727	766	805	844	883
112	3.5)	4911	960	999	037	076	115	153	192	230	269
113		5307	346	384	422	461	499	537	576	614	652
114	9.6)	5690	728	766	804	842	880	918	956	994	032
115		3.06069	107	145	182	220	258	295	333	370	408
116		3.06446	483	520	557	595	632	669	707	744	781
117	5,7)	6818	855	892	929	966	003	040	077	114	151
118		7188	224	261	298	335	371	408	445	481	518
119		7554	591	627	664	700	736	773	809	845	881
120		7918	954	990	026	062	098	134	170	206	242
121	3.8)	8278	314	350	386	421	457	493	529	564	600
122		8635	671	707	742	778	813	849	884	919	955
123	1.9)	8990	025	061	096	131	166	201	236	272	307
124		9342	377	412	447	482	516	551	586	621	656
125	9.10)	9691	725	760	795	829	864	898	933	968	002
126		3,10937	071	105	140	174	209	243	277	311	346

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127		3.10380	414	448	482	516	551	585	619	653	687
128	9.1)	721	754	788	822	856	890	924	957	991	025
129		1058	092	126	159	193	226	260	294	327	360
130		3.11394	427	461	494	527	561	594	627	660	693
131	9.2)	727	760	793	826	859	892	925	958	991	024
132		2057	090	123	155	188	221	254	287	319	352
133		385	417	450	483	515	548	580	613	645	678
134	9.3)	710	742	775	807	839	872	904	936	968	001
135		3033	065	097	129	161	193	225	257	289	321
136		353	385	417	449	481	513	545	576	608	640
137		3,13672	703	735	767	798	830	861	895	924	956
138	1.4)	987	019	050	082	113	144	176	207	238	270
139		4301	332	363	395	426	457	488	519	550	581
140		3.14612	643	674	705	736	767	798	829	860	891
141	3.5)	921	952	983	014	044	075	106	136	167	198
142		5228	259	289	320	351	381	411	442	472	503
143		533	563	594	624	654	685	715	745	775	806
144	6,6)	836	866	896	926	956	986	016	046	076	106
145		6136	166	196	226	256	286	316	345	375	405
146		435	465	494	524	554	583	613	943	672	702
147		3.16731	761	790	820	849	879	909	938	967	996
148		7026	055	084	114	143	172	201	231	260	289
149		318	347	376	405	435	464	493	522	551	580
150		3,17609	638	666	695	724	763	782	811	840	868
151	4,8)	897	926	955	983	012	041	069	098	127	155
152		8184	212	241	269	298	326	355	383	412	440
153		469	497	525	554	582	610	639	667	695	723
154	9.9)	752	780	808	836	864	892	920	949	977	005
155		9033	061	089	117	145	173	200	228	256	284
156		312	340	368	395	423	451	479	506	534	562
157		589	617	645	672	700	672	700	728	755	783
158	5,20)	865	893	920	948	975	002	030	057	085	112
159		3.20139	167	194	221	248	276	303	330	375	384
160		412	439	466	493	520	547	574	601	628	655
161		682	709	736	763	790	817	844	871	897	924
162	2,1)	951	978	005	031	058	085	112	138	165	192
163		1218	245	272	298	325	351	378	404	431	457
164		484	510	537	563	590	616	642	669	695	722
165		748	774	801	827	853	879	906	932	958	984
166		2010	036	063	089	115	141	167	193	219	245
167		271	297	323	349	375	401	427	453	479	505
168		530	556	582	604	634	659	685	711	737	672

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169	9,3) 3.22788	814	840	865	891	916	942	968	993	019
170	3,23044	070	095	121	146	172	197	223	248	275
171	299	325	350	375	401	426	451	477	502	527
172	552	578	603	628	653	678	704	729	754	779
173	8,4) 804	829	854	879	904	929	954	979	004	029
174	4054	079	104	129	154	179	204	229	254	278
175	303	328	393	378	402	427	452	477	501	526
176	551	575	600	625	649	674	699	723	748	772
177	9.5) 797	821	846	870	895	919	944	968	993	017
178	5042	066	090	115	139	163	188	212	236	261
179	281	309	333	358	382	406	430	454	478	503
180	3.25527	551	575	599	623	647	671	695	719	743
181	767	791	815	839	863	887	911	935	959	983
182	6007	030	054	078	102	126	150	173	197	221
183	245	268	292	316	339	363	387	410	434	458
184	481	505	528	552	576	559	613	646	670	698
185	717	740	764	787	801	834	857	881	904	927
186	3,7) 951	974	997	021	044	067	091	114	137	160
187	7184	207	230	253	276	300	323	346	369	392
188	415	438	461	485	508	531	554	577	600	623
189	3,27646	669	692	715	738	760	783	806	829	852
190	6.8) 3,27875	898	921	943	966	989	012	035	057	080
191	8103	126	148	171	194	216	239	262	284	307
192	330	352	375	397	420	443	654	488	510	533
193	555	578	600	623	645	668	690	712	735	757
194	780	802	824	847	869	891	914	936	958	981
195	9003	025	047	072	092	114	136	159	181	203
196	225	247	269	292	314	336	358	380	402	424
197	446	468	490	512	534	556	578	600	622	644
198	666	688	710	732	754	776	797	819	841	863
199	6.30) 885	907	928	950	994	994	016	037	059	081
200	3,30103	124	146	168	189	211	233	255	276	298
201	3,30319	341	363	384	406	427	449	471	492	514
202	535	556	578	599	621	642	664	685	707	728
203	749	771	792	814	835	856	878	899	920	942
204	2,1) 963	984	055	027	048	069	091	112	133	154
205	1175	196	218	239	260	281	302	323	345	366
206	386	408	429	450	471	492	513	534	555	576
207	597	618	639	660	680	702	723	744	765	785
208	806	827	848	869	889	911	931	952	973	994
209	2014	035	056	077	097	118	139	160	181	201
210	222	24	263	284	304	325	346	366	387	408

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211		3,32428	449	469	490	510	531	552	572	593	613
212		633	654	674	695	715	736	756	777	796	817
213	8.3)	837	858	879	899	919	931	960	980	001	021
214		3041	062	082	102	122	143	163	183	203	224
215		244	264	284	304	324	345	365	385	405	425
216		445	465	485	505	526	546	566	586	606	626
217		645	666	686	706	726	746	766	786	806	826
218	8.4)	845	865	885	905	925	945	965	985	005	025
219		4044	064	084	104	124	143	163	183	203	223
220		242	262	281	301	321	341	361	380	400	420
221		3,3444	459	478	498	518	537	557	576	596	616
222		635	655	674	694	713	733	553	772	792	811
223	9.5)	830	850	869	889	908	928	947	967	986	005
224		5025	044	063	083	102	122	141	160	180	199
225		218	237	257	276	295	315	334	353	372	392
226		411	430	449	468	488	507	526	545	564	583
227		602	622	041	060	079	698	717	736	755	774
228		793	812	831	850	869	889	908	923	946	965
229	1,6)	983	002	021	040	059	078	097	116	135	154
230		6173	192	210	230	248	267	286	305	324	342
231		3,36361	680	399	317	436	455	474	491	513	530
232		549	567	586	605	624	642	661	680	698	717
233		733	754	773	791	810	829	847	366	884	903
234	5,7)	921	940	959	977	996	014	033	051	070	088
235		7107	125	144	162	181	200	218	236	254	273
236		291	309	328	346	365	383	401	419	438,	457
237		475	493	511	530	548	566	585	603	621	639
238		658	676	694	712	731	749	767	785	803	822
239	9,8)	839	858	876	894	912	931	949	967	985	003
240		3.38021	039	057	075	093	112	130	148	166	184
241		3,38202	221	238	256	274	292	310	328	346	364
242		382	399	417	435	453	471	489	507	525	543
243		561	578	596	614	632	650	668	686	703	721
244		739	757	774	792	810	828	846	863	881	899
245	5.9)	917	934	952	969	987	005	023	041	058	076
246		9093	111	129	146	164	182	199	217	235	252
247		270	287	305	322	340	358	375	393	410	428
248		445	463	480	498	515	531	550	568	585	602
249		620	637	655	672	690	707	724	742	759	777
250		3.39794	811	829	846	863	881	898	915	933	950
351	2,49)	967	985	002	019	037	054	071	088	106	123
252		40140	157	175	192	209	226	243	261	278	295

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253	3,40312	329	346	364	381	398	415	432	450	466
254	483	500	518	535	552	569	536	603	620	637
255	654	671	688	705	722	739	756	773	790	807
256	824	841	858	875	892	909	926	943	960	976
257	1,1) 993	010	027	044	061	078	095	111	128	145
258	1162	179	196	212	229	246	263	280	296	313
259	330	347	363	380	397	414	430	447	464	481
260	3,41497	514	531	547	565	581	598	614	631	647
261	664	681	697	714	731	747	764	780	797	814
262	830	847	863	880	896	913	930	946	963	980
263	1,2) 996	012	029	046	062	078	095	111	127	144
264	3,42160	177	193	210	226	243	259	275	292	308
265	325	341	357	374	390	406	423	440	456	472
266	488	504	521	537	553	570	586	602	619	635
267	651	667	684	700	716	732	749	765	781	797
268	813	830	846	862	878	884	911	927	943	960
269	2,3) 975	991	008	024	040	056	072	088	104	120
270	3,43136	152	169	185	201	217	233	249	265	281
271	297	313	329	345	361	377	393	409	425	441
272	457	473	489	505	521	537	553	569	584	660
273	616	632	648	664	680	696	712	727	743	760
274	3,43775	791	807	823	838	854	870	886	902	917
275	5,4) 933	950	965	981	996	012	028	043	059	075
276	4090	107	122	138	154	170	185	201	217	232
277	248	264	279	295	311	326	342	358	373	389
278	404	420	436	451	467	483	496	514	530	545
279	560	576	592	607	623	638	654	670	685	700
280	3·44716	731	747	762	778	793	809	824	840	855
281	9·5) 871	886	902	917	932	948	963	979	994	010
282	5025	040	056	071	086	102	117	133	148	163
283	170	194	209	225	240	255	271	286	301	317
284	3·45332	347	362	378	393	408	423	439	454	470
285	484	500	515	530	545	561	576	591	606	621
286	637	652	667	682	697	712	728	743	758	773
287	788	803	818	834	849	864	879	894	910	924
288	5·6) 939	954	969	984	999	015	030	045	060	075
289	6090	105	120	135	150	165	178	195	210	225
290	240	255	270	285	291	315	330	345	359	374
291	3·46390	404	420	434	449	464	479	494	508	523
292	538	553	568	583	598	613	627	642	657	672
293	687	702	716	731	746	761	776	790	805	820
294	835	850	864	879	894	909	923	938	953	968

Nu.	0	1	2	3	4	5	6	7	8	9
295	2,7) 3,46892	907	012	026	041	056	070	085	100	115
296	7130	144	159	178	189	202	217	232	246	261
297	276	290	305	320	334	349	363	378	392	407
298	422	436	451	465	480	494	509	524	538	555
299	567	582	596	610	625	640	654	669	683	698
300	712	726	740	756	770	784	799	813	824	842
301	3,47857	871	886	900	914	929	943	958	972	986
302	8000	015	030	044	058	073	087	101	116	130
303	144	159	173	187	202	216	236	244	259	273
304	287	302	316	330	344	359	373	387	402	416
305	3,48430	444	458	473	487	501	515	530	544	558
306	572	586	601	615	629	643	657	671	686	700
307	714	727	742	756	770	785	799	813	827	841
308	855	869	883	897	911	926	940	958	968	982
309	1.9) 996	010	024	038	052	066	080	094	108	122
310	9136	150	164	178	192	206	220	234	248	202
311	3.49276	290	304	318	332	346	360	374	388	402
312	415	429	443	457	471	485	499	513	527	541
313	554	568	582	596	610	024	638	651	665	680
314	693	707	721	734	748	762	776	790	803	817
315	3,49831	845	859	872	886	900	914	927	941	955
316	3,5) 969	982	996	010	024	037	051	065	079	092
317	50106	120	133	147	161	174	188	202	215	229
318	243	256	270	284	297	311	325	338	352	365
319	379	393	403	420	433	447	461	474	488	501
320	3.50515	529	542	556	570	583	596	610	623	637
321	651	664	678	691	705	718	732	745	759	772
322	781	799	813	826	840	853	866	880	893	907
323	6.1) 920	934	947	961	974	987	001	014	028	041
324	1054	068	081	095	108	121	135	148	162	175
325	188	202	215	228	242	255	268	282	295	308
326	3,51322	334	348	362	375	388	402	415	428	441
327	455	468	481	495	508	521	534	548	561	574
328	587	601	614	627	640	653	667	680	693	706
329	720	731	746	759	772	786	799	812	825	838
330	851	865	878	891	904	917	930	943	957	970
331	2,2) 3.51983	996	009	022	035	048	061	075	088	101
332	2114	127	134	153	166	179	192	205	218	231
333	244	257	271	284	297	309	323	336	349	362
334	375	388	404	414	427	440	453	466	479	492
335	504	517	530	543	556	570	582	595	608	621
336	634	647	660	673	686	699	711	724	737	750

Nu.	0		1	2	3	4	5	6	7	8	9
337		3·52763	776	789	802	815	827	840	853	866	879
338	9·3)	892	905	917	930	943	956	969	982	994	007
339		3020	033	046	058	071	084	195	110	122	135
340		148	161	173	186	199	212	224	237	250	263
341		3·53275	288	301	314	326	340	352	365	377	390
342		403	415	428	441	453	466	479	491	503	517
343		529	542	555	567	580	593	609	618	631	643
344		656	668	681	694	706	719	732	744	757	770
345		782	795	807	820	832	845	857	869	882	895
346	8,4)	908	920	933	945	958	970	983	995	008	020
347		3·54033	045	058	070	083	095	108	121	133	145
348		158	170	183	195	208	220	233	245	258	270
349		283	295	307	320	332	345	357	370	382	394
350		407	419	432	444	456	469	481	494	506	518
351		3·54531	543	555	568	580	593	605	617	630	642
352		654	667	679	691	704	716	728	741	753	765
353		777	790	802	814	827	839	851	864	877	888
354	9·5)	900	913	925	937	950	962	974	986	998	010
355		5023	035	047	060	072	084	096	108	121	133
356		145	157	169	182	194	206	218	230	242	254
357		3·55267	279	291	303	315	327	340	353	364	376
358		388	400	413	425	437	449	461	473	489	497
359		509	522	534	546	558	570	582	594	606	618
360		3,55630	642	654	666	678	691	702	714	727	739
361		750	763	774	787	799	811	823	835	847	859
362		871	883	895	907	919	931	943	995	967	979
363	1.6)	6991	003	015	026	039	050	062	074	086	098
364		110	122	134	146	158	170	182	194	209	217
365		229	241	253	265	277	289	301	313	324	336
366		348	360	372	384	395	407	420	431	443	455
367		467	478	490	502	514	526	538	549	561	573
368		3,56585	596	608	620	632	644	656	667	679	690
369		703	714	726	738	750	761	773	785	797	808
370		820	832	844	855	867	879	891	902	914	925
371	6.7)	6937	949	961	972	984	996	007	010	031	043
372		7054	066	078	089	101	113	124	136	147	160
373		171	182	194	206	217	229	241	252	264	275
374		287	299	310	322	333	345	357	368	380	391
375		403	415	426	438	450	461	472	484	496	507
376		519	530	542	553	565	576	588	599	611	623
377		634	646	657	669	680	692	703	715	726	738
378		749	761	772	784	795	806	818	829	841	852

Nu.	0	1	2	3	4	5	6	7	8	9
379	3.57864	875	887	898	910	921	931	944	955	967
380	2.8) 978	910	001	012	024	035	047	058	069	081
381	3.58092	104	115	127	138	149	161	172	183	195
382	206	218	229	240	252	263	274	286	297	308
383	320	331	342	354	365	376	388	399	410	422
384	433	444	456	467	478	490	501	512	523	535
385	546	557	569	580	591	602	614	625	636	647
386	659	670	681	692	704	715	726	737	749	760
387	771	782	794	805	816	827	838	849	861	872
388	883	894	906	917	928	939	950	961	971	984
389	1,9) 995	006	017	028	039	051	062	073	084	095
390	3.59106	117	129	140	151	162	173	184	195	206
391	3,59218	229	240	251	262	273	284	295	306	317
392	329	340	351	362	373	384	395	406	417	428
393	439	450	461	472	483	494	505	516	527	539
394	550	561	572	583	594	605	616	627	638	649
395	660	671	682	693	704	715	726	737	747	758
396	769	780	791	802	814	824	835	846	857	868
397	879	890	901	912	923	934	945	955	966	977
398	2,60) 988	999	010	021	032	043	054	065	071	086
399	60097	108	119	130	141	152	162	173	184	195
400	3,60314	217	228	238	249	260	271	282	293	304
401	314	325	336	346	357	368	379	390	401	412
402	422	433	444	455	466	477	487	498	509	520
403	530	541	552	563	574	584	595	606	617	627
404	638	649	659	670	681	692	703	713	724	735
405	745	756	767	778	788	799	810	821	831	842
406	852	863	874	885	895	906	917	927	938	949
407	4,1) 959	970	981	991	002	013	023	034	045	055
408	1066	077	087	097	109	119	130	140	151	162
409	172	183	193	204	215	225	236	247	257	268
410	278	289	300	310	321	331	342	351	363	374
411	3,61 384	395	405	416	426	437	448	458	469	479
412	489	500	511	521	532	542	553	563	574	584
413	595	606	616	626	637	647	658	669	679	690
414	700	710	721	731	742	752	763	773	784	794
415	805	815	826	836	847	857	868	878	888	899
416	9,2) 909	920	930	941	951	962	972	982	993	003
417	2013	024	034	045	055	066	076	086	097	107
418	117	128	138	149	159	169	180	190	201	211
419	221	232	242	252	263	273	284	294	304	315
420	325	335	346	356	366	377	387	397	408	418

A TABLE *of Points, and Quarters, with the Degrees, and Minutes correſponding, alſo their Natural Sines, Co. Sines, Tangents, and Co. Tangents.*

Points	Deg.	mi.	N. Si.	N. c. ſi.	N. tan	N. Co,tan,
¼	2	49	,049	,998	,049	20,5
½	5	37	,098	,995	,098	10,2
¾	8	26	,147	,989	,148	6,74
1	11	15	,195	,980	,199	5,03
1¼	14	4	,243	,970	,250	3,99
1½	16	52	,290	,960	,303	3,29
1¾	19	41	,337	,942	,358	2,79
2	22	30	,383	,924	,414	2,41
2¼	25	19	,430	,904	,473	2,11
2½	28	7	,471	,882	,535	1,87
2¾	30	56	,514	,858	,599	1,67
3	33	45	,555	,831	,669	1,50
3¼	36	34	,596	,803	,741	1,35
3½	39	22	,634	,772	,820	1,22
3¾	42	11	,671	,741	,906	1,10
4	45	0	,707	,707	1,00	1,00
4¼	47	49	,741	,671	1,10	,906
4½	50	38	,772	,634	1,22	,820
4¾	53	26	,803	,596	1,35	,741
5	56	15	,831	,555	1,50	,669
5¼	59	4	,858	,514	1.67	,599
5½	61	53	,882	,471	1,87	,535
5¾	64	41	,904	,430	2,11	,473
6	67	30	,924	,383	2,41	,414
6¼	70	19	,942	,337	2,79	,358
6½	73	8	,960	,290	3,29	,303
6¾	75	56	,970	,243	3,99	,250
7	78	45	,980	,195	5,03	,199
7¼	81	34	,989	,147	6,74	,148
7½	84	23	,995	,098	10,2	,098
7¾	87	11	,998	,049	20,5	,049
8	90	0	1,00	1,00	Infinite	,000

A TABLE *of the Angles, which every Point and Quarter o the Compaſs makes with the Meridian, ſerving by inſpection t turn Rumbs into Degrees, and the contrary.*

Rumbs North	Rumbs South	Pts	De. mi.	Rumbs North	Rumbs South
		0	00 00		
		¼	2 49		
		½	5 37		
		¾	8 26		
N. b. E.	S. by E.	1	11 15	N. by W.	S. by W.
		1¼	14 4		
		1½	16 52		
		1¾	19 41		
N. N. E.	S. S. E.	2	22 30	N. N. W.	S. S. W.
		2¼	25 19		
		2½	28 7		
		2¾	30 56		
N.E.b.N.	S.E.b.S.	3	33 45	N.W.b.N.	S.W.b.S.
		3¼	36 34		
		3½	39 22		
		3¾	42 11		
N. E.	S. E.	4	45 0	N. W.	S. W.
		4¼	47 49		
		4½	50 38		
		4¾	53 26		
N.E.b.E.	S.E.b.E.	5	56 15	N.W.b.W.	S.W.b.W.
		5¼	59 4		
		5½	61 53		
		5¾	64 41		
E. N. E.	E. S. E.	6	67 30	W. N. W.	W. S. W.
		6¼	70 19		
		6½	73 8		
		6¾	75 56		
E. b. N.	E. by S.	7	78 45	W. by N.	W. by S.
		7¼	81 34		
		7½	84 23		
		7¾	87 11		
Eaſt.	Eaſt.	8	90 0	Weſt.	Weſt.

A Short and Correct Method of determining the Latitude from two Obſervations of the Sun, and the intermediate Time.

Ex. 1ſt. Admit on June the 22d. at 9h. 30m. A.M. the ſun's altitude, 48d. 10m. and at 10h. 30m. the ſun's altitude 54d. 10m. Required the latitude?

The OPERATION.

	Half the time (at 15d. to 1h.) is	7d.	30m.	ſine	9.11569	} +
	Sun's declination	23	28	co. ſine	9.96250	}
		6	53	ſine	9.07819	
		×	2			
+ {	Sine	13	46	co ar.	0.62349	]
	Com. of 2d. alt. ſine	35	50	ditto	0.23253	
	Com. of 1ſt, alt.	41	50			
	Sum	90	26			} +
— {	Half ſum	45	43	ſine	9.85484	
	Sub. co. of 1ſt. alt.	41	50			
	Difference	3	53	ſine	8.83074	]
	Sum of ſines and co, ar. of ſines				19.54160	
	Co. ſine	53	51	= half	9.77080	
		×	2			
		107	42	which call B		
	Then tang. of half the time	7	30		9.11942	} +
	Sine of Declination	23	28	No.	9.60011	}
	Co. tangent	87	00		8.71953	
	which ſubtract from B	107	42			
	Difference	20	42	co. ſine	9.97101	} +
	Co. tang. of 2d. altitude	54	10		9.85860	}
	which call C equal	34	02	tangent	9.82961	
	which ſubtract from	66	32	com. of declination		
		32	30	co. ſine	9.92602	]
	Sine of 2d. altitude	54	10		9.90887	} +
	Co. ſine of C	34	02	co. ar.	0.08160	]
	Sine of the latitude N.	55	35		9.91649	

N. B. The ſun's declination muſt be calculated to the meridian of the place, and middle time of obſervations.

To find The Latitude by Two Obſervations.

Ex. 2d. Admit on December 20th, at 10 o'clock A. M. ſun's altitude 24d. 10m. and three quarters of an hour after, ſun's altitude 30d, 00m. Required the latitude?

The OPERATION.

	Half the time (at 15d. to 1h.) is	5d.	37m.	ſine	8.99066	+
	Sun's declination	23	28	co. ſine	9.96250	
		5	09	ſine	8.95316	
		× 2				
+	Sine	10	18	co. ar.	0,74763	+
	Co. of ſecond alt, is	60	00	Ditto	0,06247	
	Ditto firſt	65	50			
	Sum	136	08			
−	Half Ditto	68	04	ſine	9,96736	
	Sub, Co. of firſt alt.	65	50			
	Difference	2	14	ſine	8,59072	
		Sum			19,36818	
	Co, Sine	61	06	= half	9,68409	
		× 2				
		122	12	which call B.		
	Then tang, of half the time	5	37		8,99275	+
	*S*ine Declination	23	28	ſouth	9.60011	
	Co, tangent	87	46		8,59286	
	which ſubract from	180	00	when declination is contrary to the lat.		
	Remains	92	1			
	Subtract from B	122	12			
	Difference	29	58	co, ſine	9,93767	+
	Co, tang, of 2d, altitude	30	00		10,23856	
	which call C equal	56	19	tang,	10,17623	
	which ſubtract from	113	28	(=90d. + declination)		
		57	09	co, ſine	9.734 5	+
	Sine of ſecond alt,	30	00		9,69897	
	Co. ſine of C	56	19	co. ar,	0,25612	
	Sine of the latitude N.	29	17		9,68944	

FINIS.

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